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RESEARCH

Baseline patient profiling and three-year outcome data after metabolic surgery at a South African centre of excellence

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The bariatric team at Waterfall City Hospital in Gauteng has performed 820 metabolic surgeries under the guidance of an extended team, and with comprehensive recordkeeping. Baseline profiling on more than 50 variables afforded insight into patients undergoing surgery. The available outcome data over three years were comparable with those in the documented literature. The attempted weight loss period prior to agreeing to surgery was 16–18 years. Weight loss in the overall cohort was 29% at three years, with a two-year outcome as follows: diabetes mellitus remission of 81.6% in males and 83.1% in females, full and part-hypertension resolution of 84.8% in males and 74.6% in females, hyperlipidaemia on no treatment of 76.8% in males and 72.1% in females, and sleep apnoea of 75.5% in males and 76.8% in females. Separating out the diabetic group indicated a diabetes mellitus remission of 73.9% in males and 75.1% in females at one year. Improvement in the components of metabolic syndrome was demonstrated in the total cohort. There was an worse profile and higher risk in the male patients. Similarly, higher risk was recorded in the biliopancreatic diversion-duodenal switch cohort, and there was a higher percentage of elected diabetic patients. A wide range of revision surgery was performed, with a higher complication rate (20%) experienced compared to that recorded with the primary surgeries. The morbidity data were separated into medical and surgical morbidity. Major medical morbidity was documented at 5.6% and surgical morbidity at 3.9%. Surgical morbidity in the first 250 cases was reported to be 6% *vs.* 2.7% in the last 570 cases. Mortality for the cohort was noted to be 0.1%.

Keywords: bariatric surgery, outcome data, profiling, South Africa

Introduction

Countries in transition from being undeveloped to developed, such as South Africa, are currently affected by the rapid rise in noncommunicable diseases, such as obesity.[1] An increased rate of obesity is prevalent across all economic levels, and ethnic and age groups.[2] Associated diseases, such as type 2 diabetes mellitus, hypertension and ischaemic heart disease (IHD) are high in the population,[3–5] and pose a challenge to the government and private sector medicine. Combined figures obtained in 1998 for obesity and overweight (body mass index (BMI) > 25 kg/m^2) in the adult population across all ethnic groups were 57% for women and 29% for men.[6] This trend has been confirmed by more recent data from the early 2000s.[7] Morbid obesity (BMI > 40 kg/m^2) has not been determined in any the meaningful longitudinal studies in South Africa, but the prevalence of obesity (BMI > 30 kg/m^2) is estimated to be between 20% and 34% in women and between 3% and 20% in men, depending on the ethnic group and socio-economic standing.[8] Misrepresentation of health information from the 1960s until the late 1980s led to the concept of "benign obesity" in the black population.[9] This concept has compounded the problem of rampant obesity and diabetes in South for many years in certain ethnic groups.[10]

Obesity prevention and treatment should be multifaceted and tailored to every country's demographics, socio-political circumstances, pathophysiology and resources. In order to secure maximum benefit for economic resources, it is essential that research and interpretation are based on ongoing and accurate data collection with respect to baseline patient profiles in each treatment modality. In addition, outcome data need to be collected.

A programme for a Centre of Excellence for Metabolic Medicine and Surgery SA was launched in South Africa in 2005. The centres are administered by a single administrative office. The centre at Netcare Waterfall City Hospital performs 70% of the volume of metabolic surgery for Netcare Limited in South Africa. Since metabolic surgery appears to be markedly more efficient than the usual care for diabetes mellitus management in the obese,[11,12] as well as being more successful in the prevention of diabetes mellitus,[13] it is imperative that healthcare services employ a definitive strategy to grow this field of medicine in the future. Therefore, the main aim of the paper was to document baseline and outcome data in South Africa for the first time, and to create a template for future and ongoing critical analysis pertaining to the arena of funders and health economics in this country.

Method

Patient variables were collected prospectively and consecutively using a custom-designed programme at baseline, at three months and then annually. Data collection took place over a period of four consecutive years. Data were entered and stored on the database in a blinded manner. Data collection was performed with the written consent of the patients, in accordance with the Helsinki Declaration of 1961, and with the permission of the Netcare Limited ethics committee. Chemical, clinical and radiological analyses form part of patients' routine preparation, management and follow-up data collection. Variables at baseline included 50 clinical, biochemical, psychological, dietary and social parameters. Data collection and follow-up were carried out by a single designated endocrinologist, metabolic surgeon, psychologist, psychiatrist and two dietitians. A 6–12 month window period was

incorporated to capture the data on remission. This was needed in order to accommodate a time variance in the patients' follow-up schedules and the database kept for percentage statistics on the follow-up visits, and therefore was independent from the biochemical data.

The data were analysed with the XLSTAT® programme, version 2011. Annual clinical and biochemical variables were examined using an unpaired Student's *t*-test and the percentage presence of a variable, calculated on the total number (*n*) entered for a particular variable. Risk scoring and validation were based on the previous publication by van der Merwe and van der Walt.[14]

Patients were weighed in very light clothing on a Seca® scale, model 4413211104. The scales were calibrated in a regular and an identical manner. Weight was measured to one decimal place. Height was taken with the participants standing upright, without shoes, against a scale-attached ruler, and rounded to the nearest centimetre. The waist and hip circumferences were taken, as previously described by van der Merwe et al.[15]

Percentage body fat was measured with a GE Lunar Prodigy® scanner, serial number 77060GA, for patients weighing < 180 kg. Gallstones and hepatic steatosis were detected in a standardised manner by a single radiology practice, using a GE IEC® 60601–1 sonar machine. The fasted biochemical serum samples reported here were collected for: glucose (3.9–6.0 mmol/l), triglycerides (TGs) (0.4–1.6 mmol/l), low-density lipoprotein (LDL) cholesterol (1.5–2.9 mmol/l), high-density lipoprotein (HDL) cholesterol (1.2–1.9 mmol/l), alanine transaminase (ALT) (< 35.0 UI), aspartate transaminase (AST) (< 32.0 UI), gamma-glutamyl transferase (< 40.0 UI), C-reactive protein (CRP) (< 5.0 mg/l) and uric acid (0.16–0.36 mmol/l). Beckman® DxC800 pathology analysis was applied throughout.

Resolution of type 2 diabetes mellitus was taken to be a normal fasting glucose (FG) of < 3.9–6.0 mmol/l and haemoglobin A_{1c} of < 4.0–6.0% (Roche® Integra 400), with the patient not requiring medication. Partial resolution of type 2 diabetes was reported to have occurred when a patient still required ongoing drug therapy to maintain normal biochemical values. The resolution of hyperlipidaemia was reported to have taken place when variables in the normal range for TGs 0.4–1.6 mmol/l, LDL cholesterol 1.5–2.9 mmol/l and HDL cholesterol 1.2–1.9 mmol/l, were reported, while requiring no drug therapy. Partial resolution occurred if the patient required ongoing pharmacotherapy to achieve a normal result. The resolution of hypertension was taken to be a reading of < 130/85 mmHg (Karotkoff sounds 1 and 4), on no medication; and partial resolution to have taken place when ongoing pharmacotherapy was required in order to obtain a similar reading. The resolution of osteoarthritis was regarded to be clinically significant in the presence of a decrease or omission of medication, ± greater mobility by the patient.

Sleep apnoea was reported to be present with an Epworth Sleepiness Scale (ESS) score of more than 12, or when an overnight sleep polysomnography laboratory indicated an Apnoea-Hypopnoea Index of > 5 events per hour. Depression, as well as eating disorders, were diagnosed by the in-house psychiatrist using the *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision* classification. Alcohol consumption was graded as per standard drink sizes in the USA containing 14 g of pure alcohol.[16,17] Polycystic ovarian syndrome (PCOS) was diagnosed using the Rotterdam 2003 criteria. The New York Heart Association Functional Classification (NHYC) criteria were applied to determine functional cardiovascular status.

A government-initiated funding programme for bariatric surgery is not available in South Africa. Funding was driven by private medical funders, or alternatively by patients who self-funded. Private medical aid funding is governed by very strict motivational criteria. Patients are considered for funding at a BMI > 35 kg/m^2 with two proven criteria, including type 2 diabetes mellitus or hypertension treated for at least six months, nonalcoholic steatohepatitis (NASH) (either biochemically or on expert radiological sonar finding), proven sleep apnoea, hypercholestrolaemia (treated for at least six months), peripheral vascular disease, proven IHD or debilitating osteoarthritis for which orthopaedic or medical management is required. These criteria have been accepted universally by funders based on calculations from actuarial teams. Alternatively, it extends to any patient with a BMI > 40 kg/m^2 who has repeatedly failed conservative intervention.

Results

The results are reported in mean ± standard error of the mean (SEM) and as percentage prevalence of the number (*n*) for a particular variable. The unpaired Student's *t*-test was used for comparisons between groups and time periods. Unless otherwise indicated, *n* for the cohort of total surgeries was 820. The metabolic surgeries performed at the centre were made up of laparoscopic gastric bypass (LGBP) (80.6%), biliopancreatic diversion-duodenal switch (BPD-DS) (8.5%), laparoscopic band (LGB) (0.2%), revision surgery (6.3%), gastric bypass via the open approach (4.2%) and Lennox-Gastaut syndrome (LGS) (2.0%).

History

The past history included a history of childhood obesity (75%), a family history of obesity (93%), more than 10 kg weight gain since the age of 18 years (93%), gestational weight gain more than 10 kg with less than 5% post-partum weight loss (42%), the presence of pharmacotherapy for obesity-related co-morbidities (78%), pharmacotherapy with known mechanism of weight gain (42%), and gestational complications resulting from obesity (14%).

The mean duration in years of attempts at weight loss was 17.3 ± 0.9 years for males, and 21.4 ± 0.6 years for females. Males consumed 2.6 ± 0.09 meals/day and females 2.1 ± 0.09 meals/day. Snack consumption was 2.1 ± 0.09 in males and 2.0 ± 0.1 in females. 17.2% of males smoked, and 16.0% of females. Alcohol intake, quantified as 3–5 units per week, was associated with 46.0% of males and 36.3% of females. Previous substance abuse with complete rehabilitation was diagnosed in 2.9% of the males and 2.5% of the females (Table 1). Patients abusing substances at the time of the study did not qualify for surgery.

The attempted use of previous pharmacotherapy for weight loss was high at 65% for males and 76% for females. A history of true eating disorders, bulimia and binge-eating disorders was relatively low, with volume and sweet eating, nibbling and stress-related eating representing most of the abnormal eating patterns. The cessation of smoking was linked to weight gain in 24% of the males and 15% of the females (Table 2). Depression, for which pharmacotherapy was required, was present in 25.5% of the males and 53.2% of the females. Anxiety for which treatment was needed was also more significant in the females at 14.2%, compared to that in the males at 6.7%. The remainder of the psychoneurological profile is outlined in Table 2.

Table 1: Gender-specific prevalence for weight loss, meal and snack intake, smoking habits, alcohol intake and substance abuse at baseline

Characteristics	Percentage (%)*	
Total (*n* = 820)	**Male (*n* = 207)**	**Female (*n* = 613)**
Years of supervised weight loss	17.3	21.4
Number of meals per day	2.6	2.1
Snack frequency per day	2.1	2.0
Cessation of smoking with > 5% weight gain	24.0	15.0
Smokers	17.2	16.0
Alcohol	46.0	36.3
Previous substance abuse	2.9	2.5

*: Expressed as a percentage of the number in the group

Table 2: Gender-specific prevalence in neuropsychiatric disorders at baseline

Characteristics	Percentage (%)*	
Total (*n* = 820)	**Male (*n* = 207)**	**Female (*n* = 613)**
Depression	25.5	53.2
Epilepsy	0.0	1.9
Schizophrenia	0.5	0.1
Bipolar disorder	1.0	3.8
Anxiety attacks	6.7	14.2
Psychosocial problems	8.3	12.9
Dementia	1.5	1.2
Idiopathic intracranial hypertension	1.0	0.9
Cerebrovascular accident (minor) and transient ischemic attack	2.0	2.8

*: Expressed as a percentage of the number in the group

Table 3: Gender-specific prevalence of major co-morbid diseases at baseline

Characteristics	Percentage (%)*	
Total (*n* = 820)	**Male (*n* = 207)**	**Female (*n* = 613)**
Hyperuricaemia and gout	47.0	19.0
Osteoarthritis	54.0	56.0
Cancer (including in situ and occult carcinoma)	10.0	11.0
Diabetes	46.0	26.0
Dyslipidaemia	63.0	49.0
Hypertension	62.0	40.0
Oesophageal reflux and erosions	64.0	63.0
NAFLD and NASH**	85.0	53.0
Sleep apnoea***	45.0	24.0
Ischaemic heart disease	13.0	6.0
Cardiomyopathy	18.0	8.0
Asthma and chronic obstructive pulmonary disease	15.0	8.0
Gallstones (previous surgery)	20.0	18.0
Renal calculi	18.0	11.0

Note: NAFLD: nonalcoholic fatty liver disease, NASH: nonalcoholic steatohepatitis
*: Expressed as a percentage of the number in the group
**: Five cases with proven cirrhosis on histology
***: Apnoea-Hypopnoea Index

Co-morbid diseases

Of the major co-morbidities, hyperuriceamia (47%), diabetes mellitus (46%), dyslipidaemia (63%), hypertension (62%), NASH and nonalcoholic fatty liver disease (NAFLD) (85%), sleep apnoea (45%), IHD (13%) and asthma and chronic obstructive pulmonary disease (15%) were higher in the male patient cohort (Table 3). The baseline and outcome data for the entire cohort of 820 patients are shown in Table 4. A significant improvement was demonstrated in all of the variables by three months, with the exception of TGs, HDL cholesterol and uric acid, for which there

Table 4: Baseline and follow-up data on the total surgical cohort

Parameter	Baseline* (*n* = 820)	3 months* (*n* = 793)	1 year* (*n* = 673)	2 year* (*n* = 503)	3 year* (*n* = 232)
Weight (kg)	127 ± 1.4	101 ± 1.2***	91 ± 1.1***	87.2 ± 2.0***	90.1 ± 3.4***
BMI (kg/m^2)	44.6 ± 0.4	36 ± 0.4***	32 ± 1.1***	30.7 ± 0.6***	31 ± 0.6***
Waist circumference (cm)	123 ± 1.0	104 ± 1.0***	95 ± 0.9***	93 ± 1.7***	97 ± 3.0***
Hip circumference (cm)	133 ± 0.8	118 ± 1.0***	113 ± 1.0***	108 ± 1.2***	111 ± 2.2***
Neck circumference (cm)	43.5 ± 0.3	38 ± 0.5**	37 ± 0.3**	36 ± 0.5***	37 ± 0.6***
SBP (mmHg)	147 ± 1.0	134 ± 0.8**	132 ± 1.0**	132 ± 1.5**	132 ± 2.3**
DBP (mmHg)	89 ± 2.0	80 ± 0.6**	79 ± 0.8**	80 ± 0.9	80 ± 1.7**
Co-morbidities	6 ± 0.1	0.5 ± 0.04***	0.5 ± 0.7***	0.5 ± 0.08***	0.5 ± 0.1***
FG (mmol/l	6.8 ± 0.1	5.3 ± 0.1**	4.9 ± 0.05**	4.9 ± 0.1***	5.0 ± 0.2***
TGs (mmol/l)	1.8 ± 0.05	1.4 ± 0.4	1.2 ± 0.04	1.1 ± 0.05**	1.2 ± 0.1**
HDL cholesterol (mmol/l)	1.1 ± 0.02	1.2 ± 0.04	1.7 ± 0.14	1.7 ± 0.05**	1.6 ± 0.08**
LDL cholesterol (mmol/l)	3.3 ± 0.05	2.2 ± 0.04	2.8 ± 0.14**	2.5 ± 0.08***	2.4 ± 0.1**
ALT (U/l)	31 ± 0.9	29 ± 0.9**	25 ± 0.9**	24 ± 1.2**	22 ± 1.4**
AST (U/l)	2 5 ± 0.5	24 ± 0.5	24 ± 0.6	23 ± 0.8	21 ± 1.4
GGT (U/l)	38 ± 2.1	26 ± 1.1**	23 ± 2.0***	19 ± 1.6***	20 ± 2.0**
Uric acid (mmol/l)	0.49 ± 0.06	0.41 ± 0.05	0.44 ± 0.02	0.3 ± 0.02***	0.3± 0.03***
CRP (mg/l)	12 ± 0.6	9 ± 0.2	5 ± 0.2**	5 ± 0.2**	5 ± 0.5**

Note: ALT: alanine transaminase, AST: aspartate transaminase, BMI: body mass index, CRP: C-reative protein, DBP: diastolic blood pressure, FG: fasting glucose, GGT: gamma-glutamyl transferase, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: systolic blood pressure, TG: triglycerides
*: Expressed as mean ± standard error of the mean
**: $p < 0.05$
***: $p < 0.01$, unpaired *t*-test compared to baseline

was a significant improvement by two years. Co-morbid diseases were significantly reduced from a mean of 5.8 ± 0.1 to 0.41 ± 0.1 years ($p < 0.01$).

Weight loss

The anthropometric variables are summarised in Table 4. Weight was reduced for the overall cohort from 127.0 ± 1.4 kg to 90.1 ± 3.4 kg ($p < 0.01$) over three years, representing a weight loss of 29.1%. The BMI at baseline for the entire cohort was recorded as 44.6 ± 0.4 kg/m^2 and 31 ± 0.6 kg/m^2 at three years at ($p < 0.01$). The baseline weight was 167.4 ± 14.0 kg and the BMI 57.9 ± 4.7 kg/m^2 for the BPD-DS patients, versus a baseline weight of 120.0 ± 4.8 kg and a BMI of 42.8 ± 1.6 kg/m^2 for the LGBP group, reflecting weight loss of 29% at the time of the one year follow-up.

Gender profiling

Of the male patients, 14% were deemed to be a significant anaesthetic risk versus 7.9% within the female cohort. This difference was accounted for by the higher prevalence of severe sleep apnoea (37.7% *vs.* 24.1%) and a higher NYHC staging in the males (42% *vs.* 33%). There was no significant difference in the litetime history taking for preoperative pulmonary embolism (5.7% *vs.* 5.1%) or deep vein thrombosis (4.8% *vs.* 5.6%) for the males versus females. The presence of infertility (14%) and PCOS (19%) in the female patients was high. A further 18% reported undefined hormonal abnormalities. Twelve per cent of the patients in the female cohort were in menopause for more than two years. Documented low serum testosterone levels were present in 15% of the males. Urinary incontinence, requiring surgical intervention, was the primary reason for referral for 4% of the patients. Three per cent of the patients had glomerulopathy, with significant renal dysfunction. Five patients underwent metabolic surgery while on haemodialysis, while awaiting renal transplantation.

It was indicated in the baseline clinical profile that the male patients had a statistically significant greater weight, BMI, waist circumference, neck circumference and blood pressure. There was no overall difference in the clinical risk scoring between the two genders. Most of the patients fell in the category of significant benefit from metabolic surgery. The slightly higher ESS score, indicating higher daytime somnolence in the males, was not significant, and did not clearly delineate between patients with established sleep apnoea on treatment, compared to those who were undiagnosed. On average, male patients had more associated co-morbid diseases (6.3 ± 0.2) than females at 5.7 ± 0.08, (Table 5).

Surgical procedures

Data were collected on 105 patients undergoing BPD-DS. The average BMI for the biliopancreatic diversion-duodenal switch (BPD-DS) cohort was 57.3 kg/m^2. The clinical and biochemical parameters for the BPD-DS group were significantly worse than those for the gastric bypass group (LGBP). On average, the former also had 1.5 more co-morbid diseases and a higher percentage of diabetes mellitus at baseline (Table 6).

Diabetic versus non-diabetic patients

The differences in the baseline measurements between diabetic and non-diabetic patients are shown in Table 7. Data were available on 251 patients with type 2 diabetes mellitus. The patients were on oral ± insulin treatment at the time of surgery. Patients with type 1 diabetes were not included in the statistical analysis. FG levels, most of the parameters of metabolic syndrome, as well as uric acid, were significantly elevated in the diabetic mellitus cohort.

The follow-up data in the diabetic cohort over three years for clinical and biochemical parameters are illustrated in Table 8. There was a significant improvement in all of the listed parameters.

Table 5: Gender-specific clinical baseline data

Characteristics	Males* (n = 207)	Females* (n = 613)
Total (n = 820)		
Waist circumference (cm)	140 ± 1.4**	116 ± 0.8
Hip circumference (cm)	137 ± 1.8	132 ± 0.8
Neck circumference (cm)	49 ± 0.7***	41 ± 0.3
Adjusted neck circumference (cm)	57 ± 1.4**	454 ± 0.5
Weight (kg)	153 ± 2.8**	119 ± 1.0
BMI (kg/m^2)	48.3 ± 0.9***	43.6 ± 0.3
SBP (mmHg)	157 ± 1.5***	143 ± 0.7
DBP (mm Hg)	93 ± 1.2***	86 ± 1.4
Average Epworth Sleepiness Scale score	12 ± 0.5	10 ± 0.3
Average co-morbid diseases	6.3 ± 0.2	5.7 ± 0.1
Clinical risk factor score	21	20
DXA body fat (%)	42	49

Note: BMI: body mass index, DBP: diastolic blood pressure, DXA: dual energy X-ray absorptiometry, SBP: systolic blood pressure
*: Expressed as mean ± standard error of the mean
**: $p < 0.01$, unpaired t-test for males versus females
***: $p < 0.05$

Table 6: Baseline data for gastric bypass procedure versus biliopancreatic diversion-duodenal switch (including laparoscopic and open surgery)

Baseline data	BPD-DS* (n = 168)	GBP* (n = 762)
Waist circumference (cm)	168 ± 13.0**	116 ± 0.8
Hip circumference (cm)	155 ± 4.5**	132 ± 0.8
Neck circumference (cm)	47 ± 3.7**	41 ± 0.3
Adjusted neck circumference (cm)	57 ± 1.4***	45 ± 0.5
Weight (kg)	168 ± 13.0**	119 ± 1.0
BMI (kg/m^2)	57.9 ± 4.5**	43.6 ± 0.3
SBP (mmHg)	151 ± 11.2****	143 ± 0.7
DBP (mmHg)	84 ± 6.0	86 ± 1.4
Co-morbidities	6.9 ± 0.2**	5.7 ± 0.1
FG (mmol/l)	6.6 ± 0.5****	6.0 ± 0.3
TGs (mmol/l)	1.6 ± 0.1****	1.7 ± 0.1
HDL cholesterol (mmol/l)	1.1 ± 0.1***	1.3 ± 0.1
LDL cholesterol (mmol/l)	3.1 ± 0.2****	3.3 ± 0.1
ALT (UI)	34 ± 2.7	31 ± 1.1
AST (UI)	27 ± 2.1	24 ± 0.9
GGT (UI)	38 ± 3.0	37 ± 1.4
CRP (mg/l)	18 ± 1.4***	10 ± 0.4
Uric acid (mmol/l)	0.5 ± 0.02	0.46 ± 0.02

Note: ALT: alanine transaminase, AST: aspartate transaminase, BPD-DS: biliopancreatic diversion-duodenal switch, BMI: body mass index, CRP: C-reactive protein, DBP: diastolic blood pressure, FG: fasting glucose, GBP: gastric bypass procedure, GGT: gamma-glutamyl transferase, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: systolic blood pressure, TG: triglycerides
*: Expressed as mean ± standard error of the mean
**: p < 0.0001, unpaired t-testfor biliopancreatic diversion-duodenal switch versus gastric bypass procedure
***: p < 0.001
****: p < 0.05

Disease remission

Gender

Compared to the male patients, a higher percentage resolution of hypertension and sleep apnoea at two years was demonstrated in the female cohort of patients. In addition, 92.0% of the females were not taking medication for co-morbid diseases at two years, compared to the 82.7% of the male patients (Table 9). No worsening diabetes was observed in the two genders.

Diabetics

Full remission of diabetes of 73.9% in the males and 75.0% in the females was documented at one year. At three years, full hypertension remission was present in 83%, full hyperlipidaemia remission in 82%, full remission of sleep apnoea in 85% and full osteoarthritis remission in 58%, of the diabetic group of patients (Table 10). The remission of additional co-morbidities is also illustrated in Table 10.

Table 7: Clinical and biochemical data on diabetic versus non-diabetic patients

Clinical and biochemical data	Diabetic* (*n* = 251)	Non-diabetic* (*n* = 549)
BMI (kg/m^2)	44.6 ± 0.4	44.5 ± 0.4
Waist circumference (cm)	123 ± 0.9	121 ± 0.8
SBP (mmHg)	147 ± 0.8	145 ± 0.7
DBP (mmHg)	88 ± 1.9	85 ± 0.5
Co-morbid diseases	5.80 ± 0.1**	4.5 ± 0.1
FG (mmol/l)	7.8 ± 0.24**	5.1 ± 0.08
Fasting TGs (mmol/l)	2.2 ± 0.06**	1.6 ± 0.08
HDL cholesterol (mmol/l)	1.0 ± 0.03**	1.4 ± 0.02
LDL cholesterol (mmol/l)	3.9 ± 0.08**	3.2 ± 0.06
ALT (UI)	43 ± 0.9***	30 ± 0.5
AST (UI)	34 ± 1.0**	23 ± 1.4
GGT (UI)	42 ± 2.0**	32 ± 3.7
CRP (mg/l)	11 ± 0.8	11 ± 0.5
Uric acid (mmol/l)	0.56 ± 0.2***	0.43 ± 0.3
DXA body fat (%)	49	44

Note: ALT: alanine transaminase, AST: aspartate transaminase, BMI: body mass index, CRP: C-reactive protein, DBP: diastolic blood pressure, DXA: dual energy X-ray absorptiometry, FG: fasting glucose, GGT: gamma-glutamyl transferase, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: systolic blood pressure, TGs: triglycerides
*: Expressed as mean ± standard error of the mean, except for percentage body fat
**: $p < 0.05$
***: $p < 0.01$, unpaired *t*-test for diabetic versus non-diabetic patients

Table 8: Diabetic outcome data over three years

Diabetic outcome data	*Baseline** (*n* = 251)	3 years* (*n* = 107)
BMI (kg/m^2)	44.6 ± 0.4	32.6 ± 1.1**
Waist circumference (cm)	123 ± 0.9	94 ± 1.7**
SBP (mmHg)	147 ± 0.8	131 ± 1.4***
DBP (mmHg)	88 ± 1.8	82 ± 1.8***
Co-morbidities	5.80 ± 0.1	0.4 ± 0.1***
FG (mmol/l)	7.8 ± 0.2	5.0 ± 0.2**
Fasting TGs (mmol/l)	2.2 ± 0.1	1.3 ± 0.1**
HDL cholesterol (mmol/l)	1.0 ± 0.1	1.69 ± 0.1***
LDL cholesterol (mmol/l)	3.9 ± 0.1	2.04 ± 0.1***
ALT (UI)	36 ± 0.8	23 ± 1.5**
AST (UI)	29 ± 0.5	22 ± 0.8***
GGT (UI)	38 ± 2.0	21 ± 2.8**
Uric acid (mg/l)	0.56 ± 0.1	0.29 ± 0.1**

Note: ALT: alanine transaminase, AST: aspartate transaminase, BMI: body mass index, DBP: diastolic blood pressure, FG: fasting glucose, GGT: gamma-glutamyl transferase, HDL: high-density lipoprotein, LDL: low-density lipoprotein, SBP: systolic blood pressure, TGs: triglycerides
*: Expressed as mean ± standard error of the mean
**: $p < 0.01$, unpaired *t*-test
***: $p < 0.05$

Nutrition, alcohol and cancer postoperatively

Food tolerance was good at three years, with only 26.1% of the patients dumping and 67.9% demonstrating a high level of compliance with their dietary instructions (Table 11). Significant alcohol intake post surgery and within the three-year follow-up was present in 4.6% of patients. Six patients (0.7%) were diagnosed with new-onset cancer in the follow-up period of three years. These included a low-grade sarcoma, non-Hodgkin's lymphoma stage 3, two intermediate- and high-grade invasive ducal breast cancers, melanoma stage 2 and prostate cancer stage 3. Four (0.5%) cases with primary hyperparathyroidism with adenomas were identified preoperatively, and underwent elective parathyroidectomies for the symptomatic relief of hypercalcemia prior to metabolic surgery.

Pre- and postoperative endoscopy and radiology

Preoperative endoscopy revealed *Helicobacter pylori* in 28.5% of patients who underwent the procedure. All *H. pylori* infections were treated with standard triple therapy, including two broad-spectrum antibiotics for seven days, as well as a proton-pump inhibitor (PPI) for 30 days.

Table 9: Gender-related difference in the resolution of disease at two years

Disease resolution	Male* (*n* = 89)	Female* (*n* = 308)
Diabetes mellitus (fully)	81.6	83.1
Diabetes mellitus (partly)	18.4	16.9
Hypertension (fully)	56.5	66.5**
Hypertension (partly)	28.3	8.1
Dyslipidaemia (no treatment)	76.8	98.9
Sleep apnoea	75.5	94.9**
Osteoarthritis (no treatment)	40.0	83.0
Osteoarthritis (incomplete)	28.9	24.7
No pharmacology	82.9	92.9

*: Expressed as a percentage of resolution for the number in the group
**: $p < 0.01$
Note: Diabetes mellitus worsened with ongoing pharmacology, diabetes mellitus treated to target

Table 10: Resolution of disease at one year in male and female diabetic patients

Disease resolution	1 year* (%)	3 years* (%)
Diabetes mellitus (fully)	65.0	87.5
Diabetes mellitus (partly)	35.0	12.5
Hypertension (fully)	70.5	83.0
Hypertension (partly)	20.5	12.0
Hyperlipidaemia (fully)	80.0	82.0
Hyperlipidaemia (partly)	8.6	1.0
Sleep apnoea	63.6	85.0
Osteoarthritis (fully)	48.5	58.0
Osteoarthritis (partly)	34.2	25.0

*: Expressed as a percentage of the number in the group

Table 11: Food tolerance and nutritional compliance over three years in the total surgical cohort

Food tolerance and nutritional compliance	1 year* (%), (*n* = 820)	3 years* (%), (*n* = 288)
Dumping	23.3	26.1
Meat tolerance	83.5	92.8
Bread tolerance	79.9	87.8
Lactose intolerance	16.3	22.8
Vomiting	0.5	2.5
Diarrhoea	2.4	1.2
Dietary compliance	82.4	67.9
Visits to the dietitian	96.2	83.1

*: Expressed as a percentage of the number in the group

Postoperative endoscopy at three months revealed that stomal ulceration was present in 4.3% of patients who tested positive for *H. pylori* preoperatively, and in 16% of patients who tested negative for this organism preoperatively. Significant ethnic differences were observed with respect to the prevalence of *H. pylori*. 23.8% of patients in the Caucasian patient population tested positive, 21.0% of the coloured patient population, 29.6% of the Indian patient population and 76.1% of the black patient population. Gallstones were diagnosed in 20.4% of patients on preoperative sonar, with cholecystectomy performed at the time of surgery. Five per cent of patients required a cholecystectomy postoperatively.

Morbidity and mortality

There was 5.6% postoperative major medical morbidity, requiring re-admission within 60 days or prolonged admission post surgery (Table 12). Minor medical morbidity at 60 days for which admission was not required was low at 2.6%, and included gastroparesis (two cases), minor pneumonia (four cases) and gout requiring multi-drug treatment (15 cases). Postoperative pulmonary embolism within six weeks from the time of surgery was documented in one patient only, and in another five patients at more than one year post surgery.

Table 12: Major medical morbidities (5.4%) relating to primary surgery for which re-admission at 60 days, or prolonged primary admission of more than seven days, is required

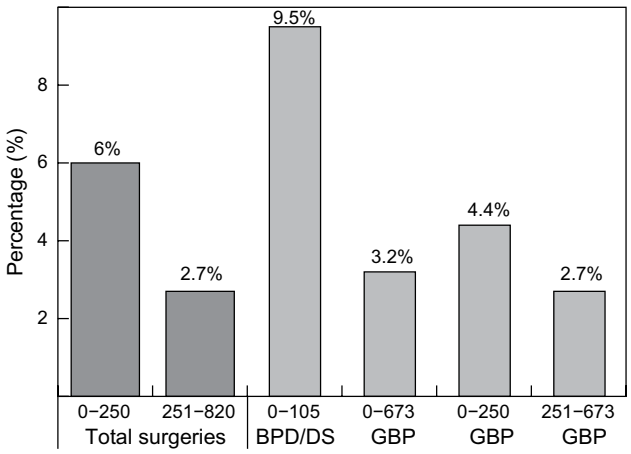
Major medical morbidity	*n*
Aspiration pneumonia	1
Pneumonia	8
Congestive cardiac failure	2
Central sleep apnoea	2
Protein malnutrition requiring total parental nutrition	7
Severe nausea syndrome	8
Severe gout	7
Kidney stones	9
Pyrexia of unknown origin	1

One medical death was reported within 30 days, and one within 90 days. The latter was a patient who advanced to a more severe stage of liver dysfunction and cirrhosis (LGBP), and the other died of suspected fatal central sleep apnoea at home on the fourth day postoperatively (LGBP). (The latter patient's family refused a post-mortem examination).

Major surgical morbidity was defined as a patient requiring admission for more than seven days, admission to the intensive care unit, or requiring re-look surgery. There was major surgical morbidity at 30 days of 3.9%.There was 6% major morbidity for the first 250 cases, and 2.7% for the next 570 cases (Figure 1). Late (> 30 day) major surgical morbidity was reported to be 3.4% in the overall cohort. Only four cases were documented in the BPD-DS group. There was no surgical mortality. Therefore, overall 30-day mortality was recorded as 0.1%, and included one medical death.

Revision surgery

Revision surgery was performed in 5.4% of patients. Of these, 1.3% was performed on patients who had undergone the primary surgery at our own centre. Open revision accounted for 77% of the surgeries. Complications were experienced in 43% of the patients. Twenty per cent were regarded as major complications, for which more than seven days of admission was required. More than 80% of the surgeries were for the reversal of jejenoileal bypass (JIB) procedures with simultaneous RYGB, removal of complicated or unsuccessful laparoscopic gastric bands with simultaneous RYGB, or revision of the RYGB to a biliopancreatic diversion. The remainder of cases included revision of the gastric pouch, revision of previous old gastric stapling of the stomach, and revision of vertical banded gastroplasty to RYGB or BPD-DS. In addition, two revisions were performed to lengthen the common limb in the primary surgery as a result of severe protein malnutrition; one for a case with BPS-DS and one for a case with long-limb LGBP.



BPD/DS: biliopancreatic diversion-duodenal switch, GBP: gastric bypass procedure.

Figure 1: Major surgical morbidity at 30 days, expressed as a percentage of the number in the group

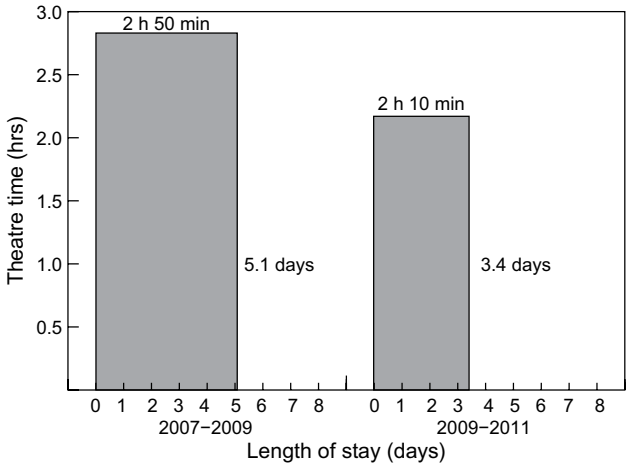


Figure 2: Reduction in theatre time and length of stay

Health economics and follow-up

Theatre time and length of stay improved significantly between 2007 and 2009, and 2009 and 2012 (Figure 2). Hospital costs increased by 23.4% over five years, from a mean of ± R45 800 to ± R59 700. This cost escalation was inclusive of inflation, an average increase in BMI of seven index points, and a more than 300% increase in the rate of BPD-DS operations. Follow-up of the patient cohort postoperatively was 96.7% at three months, 90.5% at one year, 82.1% at two years and 74.8% at three years.

Discussion

An improved understanding of the physiology of energy homeostasis and the endocrine control of food intake will form the basis of the evolution of effective therapeutic and preventative strategies in the human population. In this regard, metabolic surgery is ideally positioned to assist with potential mechanisms for novel therapies.[18] However, a clear understanding of the impact that metabolic surgery has on health problems and the long-term outcome with respect to obesity is still scarce. This is

mainly because of the lack of prospective, systematic collection of data on the baseline disease profile, and follow-up of patients undergoing this surgery. With the exception of a few long-term studies,[19–21] most studies report on medium-term outcome data, surgical complications and long-term mortality.[22–24]

Contrary to general misperception, obesity is not a disease of the last two decades only.[25] Populations with a broad range of adiposity have existed for centuries, with those in the top quartile always suffering the most adverse health consequences. However, there are still lean individuals in all populations. Thus, although the heritability of obesity is high, explaining the genetically determined inter-individual differences in susceptibility to an environment that is obesity prone, does not exclude the possibility that individuals who exert voluntary effort can achieve weight loss.[26,27] The measure of success that can be achieved in this manner is variable, and based on many biological drivers. This understanding is often lacking in the medical profession, public and media, and fosters an understanding that the "obese should be punished", and not the disease of obesity.[28] This, together with the lack of documented outcome and follow-up of bariatric surgery patients over the previous decade, has resulted in only 1% of eligible patients in the morbidly obese population being referred for and treated with metabolic surgery in the last five years, despite the 13-fold increase in surgeries in the USA and worldwide since 1992.[29,30]

Although formal health economic studies on bariatric surgery have not been performed at our own centre, every indication is there that the surgery is performed in a highly cost-effective manner. The total cost of LGBP is estimated to be $12 500, compared to $26 000 in the USA.[31,32] Theatre time reduced from 2 hours 50 minutes to 2 hours 10 minutes, over a three-year period, and includes a 10% take on BPD-DS of the total surgeries. In addition, a reduction in the documented mean of 5.8 for co-morbid diseases to 0.4, certainly places the return on capital investment on a par with that in the published literature.[33–35] The outcome with respect to a reduction in the drug classes pre- and post surgery will be available in the near future.

Our data support the observation that bariatric surgery is contemplated over 1–2 decades by patients, and that most patients present with a history of childhood obesity and a strong family history of obesity.[36] Therefore, our data also refute the notion that patients view this mode of treatment as an instant solution to their obesity problem. A very high percentage of patients attempt pharmacotherapy unsuccessfully.[37] In addition, and contrary to popular belief, we present enough evidence that these patients do not all fall into the category of severe eating disorders. On average, they overeat by 200–400 calories daily.[38]

It was found in recent studies on depression, bipolar disease and anxiety that the lifetime history of at least one axis I diagnosis is high, and that a current diagnoses of axis I disorder varies from 38–56%, and 29% for an axis II diagnosis.[39–41] Our data support this notion.

Major co-morbidities were documented with a higher prevalence in male, compared to female, patients. This could, in part, be explained by the higher BMI index in the male patients, but in view of the of the higher abdominal circumference, the role of central obesity,[42,43] as well as the role of the negative association between testosterone levels and insulin resistance in males, needs to be considered.[44–47] The evolutionary origins of insulin resistance, as discussed by Watvi and Yajnik, also need to be considered in the morbidly obese male population. According to this theory, it is speculated that the immune redistribution hypothesis is supported by the negative association between testosterone levels and insulin resistance.[48,49] Fifteen per cent of patients in our male cohort had known levels of low testosterone. This figure is expected to rise as we look for it with greater vigilance.

The BPD-DS procedure is reserved for patients with a higher BMI, and a worsened co-morbid disease profile. However, it can be stated that BMI should not be the only selection criteria.[50] A potentially higher degree of diabetes resolution in carefully selected patients is required.[11,12,51] Similarly, conclusions should not be drawn on small cohorts of patients with a short- to medium-term follow-up of two years and less.[52] The three-year outcome data on the 251 diabetic patients in the diabetic cohort were as expected owing to reports in the literature of complete remission of diabetes in 88.5% of patients,[53,54] and of comparable biochemical improvements in all the components of metabolic syndrome.[55] The patients in the overall cohort sustained an approximated 27% overall weight loss, closely resembling that in a previous meta-analysis.[56] Ten-year outcome data may not be this sustainable.[57] There was a higher percentage of complete resolution of hypertension and sleep apnoea at two years in the female patients, almost certainly as a result of the less severe baseline profile in the females. However, a differing pathology between the two genders cannot be excluded.[58] The metabolic syndrome itself might potentiate the effect of obstructive sleep apnoea on cardiovascular disease, with the most profound risk expressed in the morbidly obese category.[59,60]

Nonalcoholic fatty liver disease (NAFLD) includes a broad spectrum of liver tissue alterations, ranging from pure steatosis to cirrhosis, through to NASH. Obesity, especially central obesity, is the metabolic condition most closely associated with steatosis and NASH.[61] The presence of NASH in the general population has been reported to be from 16–30% in prevalence studies, with an exponential increase at a BMI above 27 kg/m^2.[62] There was a high prevalence of NASH, either on sonography or biochemistry, in both male and female patients in our patient cohort, but significantly more so in the male patients (75% *vs*. 53%). It is likely that bariatric surgery plays a role in preventing and treating advanced liver disease, but well-designed prospective trials are needed to confirm this.[63]

Estimates of obesity prevalence in female with PCOS vary from 35–60% in the literature,[64] and it is estimated that approximately 20% of females in the world carry this diagnosis.[65] There was a high prevalence of both infertility and PCOS of 14% and 19%, respectively, in our female patient cohort. It is also recognised that GBP surgery affords improvement in many clinical problems relating to PCOS.[66,67]

The rate of pulmonary embolism in our immediate (six weeks) postoperative patient cohort was low, and most likely to be the result of careful patient selection and screening, early mobilisation and the stringent application of our recommendation guidelines on the prevention of pulmonary embolism.[68] Significant postoperative alcohol consumption was reported in 4.6% of our patient population. The physiological changes after surgery could change vulnerability to problematic alcohol use, increasing the lifetime risk of alcohol use disorders, and greater sensitivity to the intoxicating effects of alcohol.[69] Adequate alcohol consumption screening, and preoperative preparation could assist in mitigating this risk.[16]

It is important that metabolic surgery patients adhere to specific follow-up and dietary recommendations.[70,71] RYGB surgery leads to substantial changes in the neural response to food cues, and the importance of this in future research and outcome-based studies is paramount to the long-term success of metabolic surgery.[72]

The presence of *H. pylori,* as part of chronic active gastritis, on preoperative endoscopy, has been documented in 85.5% of patients, in a study on morbidly obese Saudi patients undergoing bariatric surgery.[73] It was speculated that the high prevalence could have been attributed to several factors, including sanitation and socio-economic factors. We found a similarly high presence of *H. pylori* in our black patients, the reason for which remains unclear. Further prospective studies are needed to clarify the clinical importance and benefit of eradication treatment of infected preoperative patients. Currently, our practise is to treat all infected patients with an accepted antibiotic protocol and a PPI. In addition, the place for routine biopsies postoperatively has not been clarified to date.[74]

Cholelithiasis is a common following obesity surgery. Some publications suggest a rate as high as 30%.[75] It may be precipitated by rapid weight loss,[76] but the role of prophylactic cholecystectomy during obesity surgery remains controversial.[77,78] Our practise follows the guideline of the routine removal of gallbladders during obesity surgery in all BPD-DS patients, as well as that in patients with preoperative documented gallstones undergoing metabolic surgery. With this practise in place, 5% of the patients in our study required postoperative cholecystectomy.

With the increasing number of bariatric surgeries being performed, it can be expected that that the incidence of revision surgery will increase.[79] Currently, our centre performs revision in 5.4% of our patient cohort. Primary surgery of only 1.3% of our patients has been performed by us. Most of the patients require reversal of the old JIB procedure. According to the literature, the highest rate of revision is reported for the adjustable gastric band.[80] This, together with the relatively poor long-term outcome data associated with the band, in comparison to that for the GBP and BPD-DS,[81] raised our threshold for the band. Thus, we have elected not to perform this procedure at our centre. By comparison, our threshold for the BPD-DS procedure lowered over the past two years, with a significant percentage of patients qualifying for this procedure.

It is estimated that approximately 15% of GBP patients will not achieve durable weight loss. Future revision of this procedure is estimated to be 10–20%.[80] Re-operations for previous bariatric surgical complications are high in inexperienced centres, and even higher if these centres accept the revision surgery.[82] It is clear from the findings of multiple retrospective series that revision surgery is effective and beneficial in experienced han ds,[80,83,84] but data-driven algorithms for revision need to be planned and documented.

The overall risk of death and other adverse outcomes for bariatric surgery are well documented,[85,86] and the plea to have this surgery performed in high-volume accredited centres has likewise been heard.[87] However, a clear distinction between perioperative medical and surgical morbidity and mortality is made in only a few publications.[88] There is little doubt that apart from the dynamic of surgical technical expertise, the experience of the endocrinologist, anaesthetists and the extended team as a whole is ultimately the deciding factor in applying "best practise" recommendations[89] to secure low morbidity and even lower mortality.

Concise consensus statements on metabolic surgery for health professionals and medical funders need to be updated.[90] A wealth of publications has emanated in the field of obesity surgery worldwide, and yet misperceptions about the pathophysiology, perioperative mortality and morbidity, outcome data and health and economic benefits still persist in the medical profession, media and public. In addition, understandably scepticism among diabetologists, endocrinologists and physicians still needs to be addressed as they have developed fine research and treatment tools for the management of diabetes and other obesity-related co-morbidities.[91–94]

Despite certain practical and logistical limitations in the current study, we believe that it is imperative to start publishing our own "home-grown" data with a view to enriching our local knowledge base, stimulating ongoing essential research, and satisfying the overwhelming desire to continually improve what we know and practise within the Centre of Excellence for Metabolic Medicine and Surgery SA.

The role of the surgical community in the disease of obesity was eloquently outlined by Ronald Martin:[95] "The best tool, (in order) to an effective part of the solution to any problem, is always good knowledge of the fundamentals". So once again, we have to do what is required, and to perfect the role that we have to play, in order to understand obesity.

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