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RESEARCH ARTICLE

Laparoscopic Roux-en-Y Gastric Bypass and Its Early Effect on Blood Pressure

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Abstract
Background Laparoscopic Roux-en-Y gastric bypass (LRYGB) surgery is known to have a significant effect on obesity-related comorbidities such as hypertension curing it in some (50–70%) while improving control in others. Our aim was to observe the changes in blood pressure (BP) in a cohort of 100 patients followed prospectively for 1 year after LRYGB.
Methods BP measurements were recorded prospectively in 100 consecutive patients preoperatively and then postoperatively at weeks 1, 5, 9, and months 6 and 12. In order to reduce bias, three BP measurements were made by the same nurse at each office visit and the mean recorded. Pre- and postoperative usage of antihypertensive medication was also noted.
Results Eighty-nine women and 11 men underwent LRYGB and their BP monitored for 1 year. There was an 85% follow-up rate with mean % excess body weight loss of 60. Reductions in systolic (9 mmHg) and diastolic (7 mmHg) BP measurements were seen as early as week 1 postoperatively and maintained for the duration of the observation period ($P<0.05$). Furthermore, postoperative usage of antihypertensive medication is reduced to a third of preoperative use.
Conclusion LRYGB is associated with an early reduction in BP and antihypertensive medication usage which is maintained at 1 year after surgery. This early impact on blood pressure occurs before any significant weight loss is achieved thereby suggesting a hormonal mechanism that may be involved for the changes observed.

Keywords Blood pressure · Hypertension · Gastric bypass · Weight loss

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Introduction

Obesity is increasingly recognized as a major threat to human health in the developed world, with more than 120 million people worldwide classified as clinically obese. Increased weight causes increased morbidity and mortality due to its association with cardiovascular disease, diabetes, and certain cancers. Two large landmark studies have recently confirmed that bariatric surgery, especially laparoscopic Roux-en-Y gastric bypass (LRYGB), results in long-term weight loss and a significant long-term decrease in mortality in severely obese patients [1, 2].

One of the most frequent complications of obesity is hypertension [3]. Hypertension is a risk factor for cardiovascular disease and stroke. It has long been known that even a modest reduction in body weight (10%) will help reduce blood pressure (BP) [4]. Gastric bypass surgery is

not only one of the most effective methods for obesity treatment, but it also exerts the most significant effect on obesity-related comorbidities such as hypertension resolving it in some 60% [5] of patients while improving control in others [6–11]. Furthermore, the normal diurnal variation in BP which is lost in obese hypertension is restored after LRYGB [12].

Previous reports have only looked for the improvement in hypertension following a delay after surgery. The earliest documented reduction in BP has been noted 8 weeks postgastric bypass [12]. The near immediate improvement in diabetes after LRYGB has been previously documented [13]. Similarly, we noted an early reduction in BP following LRYGB and the need for reduced antihypertensive medications in our postoperative patients. We hypothesized LRYGB may have an immediate early effect on hypertension as it does on type 2 diabetes mellitus. To investigate this further, we have conducted a prospective study to examine whether LRYGB has an early effect on reducing blood pressure.

Materials and Methods

Between January 2006 and March 2006, 100 consecutive patients undergoing LRYGB at our Unit were followed up for 1 year from their operation date. Inclusion criteria were ambulatory male or female patients between 21–56 years of age meeting National Institute of Health (NIH) criteria for bariatric surgery. Patients with endocrinopathies (e.g., untreated hypo-/hyperthyroidism, cortisol excess), renal impairment, and liver impairment were excluded from the study. Patients with complicated peri- or postoperative course such as bleeding, sepsis, open conversion, and ICU admission would be included in the study on an intention to treat basis.

Blood pressure measurements were made using a Dinamap machine (Model 100, Critikon, Fl, USA) after the patients had been sitting down for 30 min. In order to reduce bias, three blood pressure measurements were made by the same nurse and the mean recorded at each office visit for the duration of the observation period. Usage of antihypertensive medication was also noted. All blood pressure measurements were made in the office setting as described above at the following times: preoperatively and then postoperatively at weeks 1, 5, 9, and months 6 and 12.

Patients' hydration status was assessed indirectly using serum urea to creatinine ratios and urine specific gravity measurements as surrogate markers to ensure there was not any change in volume status postoperatively. A comparison was made between preoperative and week 1 postoperative measurements.

Our LRYGB surgical technique has been previously described [14]. Our routine protocols were followed for all patients. Patients were told to continue using all medications in the period running up to their surgery. Immediately after surgery, all antihypertensive medications (except beta blockers) were stopped and only reintroduced if patients' BP recordings were elevated on routine postoperative nursing observation charts during their 48-h in-hospital stay. Patients were kept nil per oral on the day of surgery and started on a 1-week liquid diet (1.5-l liquid containing at least 60 g protein) thereafter. No restriction on salt intake was made.

Data Analysis

GraphPad Instat version 3 (GraphPad Software Inc., USA) was used to perform statistical analysis. The data are expressed as mean ± standard error of mean (SEM). The paired *t* test was used to compare BP at different time intervals after LRYGB to preoperative BP value. A *P* value less than or equal to 0.05 was considered to represent a significant difference.

Results

One hundred LRYGB patients were prospectively followed up for 1 year after their surgery. Eighty-nine women and 11 men, mean age 42 (23–58), mean body mass index (BMI) 49 (37–76) underwent uneventful LRYGB and their BP monitored for 1 year. The current definition of stage 1 hypertension is a systolic blood pressure of 140 mm Hg or greater or a diastolic blood pressure of 90 mm Hg or higher, and this definition was used in the present study to identify hypertensive subjects [15]. In the study group, 58 out of 100 patients were hypertensive preoperatively. Thirty-two out of the 58 hypertensive patients were receiving antihypertensive medications; the remaining 26 were untreated hypertensives. In the 42 patients who were normotensive preoperatively, 21 were receiving antihypertension medications. A total of 71 antihypertensive medications were being used by 53 patients in the group of 100 prior to LRYGB.

Table 1 demonstrates at 1 year after surgery; there was an 85% follow-up rate with mean % excess body weight loss (%EBWL) of 60. Figures 1 and 2 show reductions in systolic BP (9 mm Hg) and diastolic (7 mm Hg) BP measurements were seen as early as week 1 postoperatively and maintained for the duration of the observation period; at 1 year, a 15 mm Hg reduction in systolic BP and 9 mm Hg reduction in diastolic BP was noted ($P<0.05$).

Examining the group as a whole, the percentage of subjects defined as hypertensive dropped from 58 preoper-

Table 1 Follow-up data in patients after LRYGB

	Preoperative (N=100)	Postoperative week 1 (N=100)	Postoperative week 5 (N=91)	Postoperative week 9 (N=91)	Postoperative month 6 (N=80)	Postoperative month 12 (N=85)
Mean weight (kg)	138	132	125	120	102	93
Mean BMI	49	47	44	43	36	33
Mean %EBWL	–	7	17	25	48	60
BP systolic (mean±SEM)	134±1	125±1*	124±1*	124±1*	124±1*	119±1*
BP diastolic (mean ±SEM)	84±1	77±2*	74±1*	74±1*	74±1*	75±1*
Antihypertensive usage (total number of medications)	71	23	23	23	18	18

*P<0.05 (paired t test)

atively to 13 at week 1 and to 5 at year 1 postoperatively. Furthermore, postoperative usage of antihypertensive medication is reduced to a third of preoperative use at week 1 postoperatively and nearly to a quarter in the first year after surgery by which stage 15 patients were using a total of 18 medications.

Because patients undergoing LRYGB may have changes to their hydration status from postoperative deficit in fluid intake which may in turn influence their BP, a separate analysis was conducted to determine if there was any change in the serum urea to creatinine ratios and urinary specific gravity in patients preoperative and week 1 postoperative values. There was no significant difference in these surrogate markers for hydration status.

Discussion

Perhaps one of the largest and best-controlled studies in the field of bariatric surgery is the Swedish obese subjects study in which Sjostrom et al. reported that systolic BP decreased about 11 mm Hg and diastolic BP 7 mm Hg in the first 6 months after bariatric surgery [16]. The results of our study are in agreement with these, demonstrating a 10-m Hg reduction in systolic and diastolic BP at 6 months after LRYGB. Moreover, we demonstrate that the reduction in BP takes place at a much earlier stage with a 9- and 7-mm Hg reduction in systolic and diastolic BP, respectively, at week 1 postoperatively. This drop in BP is maintained at 1 year after surgery. Furthermore, there is an impressive reduction in usage of antihypertensive medications after LRYGB, dropping to a third of preoperative use at week 1 postoperatively and nearly to a quarter in the first year after surgery.

The effect of bariatric surgical procedures like gastric banding [17], sleeve gastrectomy [18], and biliopancreatic diversion with duodenal switch [19] on ameliorating hypertension in morbidly obese patients have been described previously. Our results are generally consistent with those of others following LRYGB [7, 8, 10, 11, 20]. There was a 58% incidence of hypertension in our study cohort,

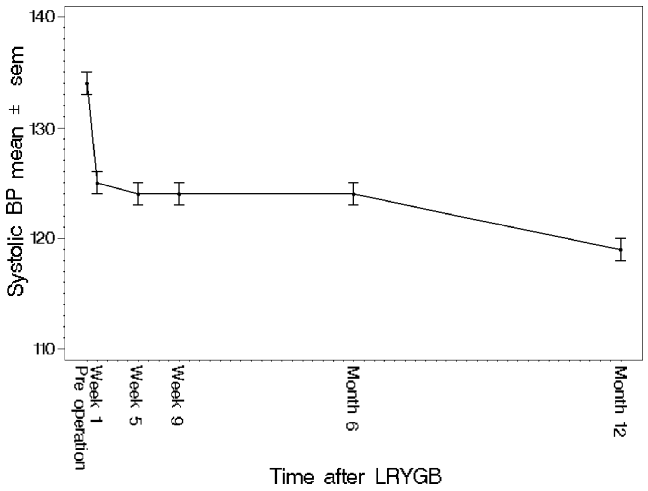

Fig. 1 Systolic blood pressure after LRYGB

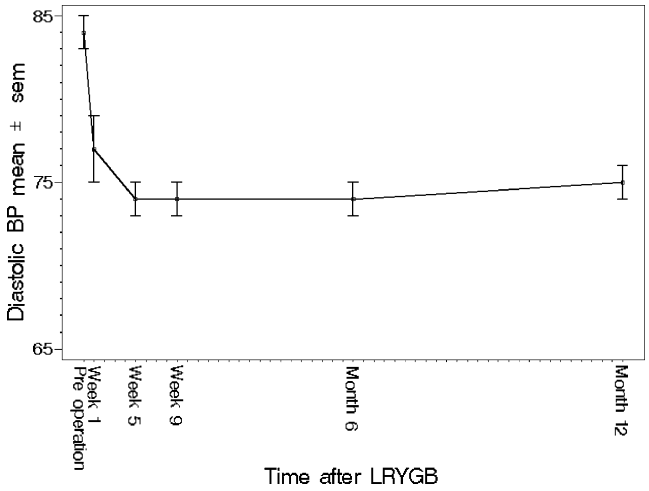

Fig. 2 Diastolic blood pressure after LRYGB

nearly half of these were untreated. There was an 88% resolution rate in hypertension in our study which is better than previously reported but it should be noted that 15 out of the initial 100 cohort were lost at 1 year follow-up. Even if it is assumed that these 15 patients did not show any improvement in their hypertension, the hypertension remission rate remains 66%. Buchwald et al. [5] noted a 62% resolution in hypertension in their systematic review of bariatric surgery. Fernstrom and colleagues [7] also noted a 55% remission rate in hypertension after surgery and found that the improvement in BP is most marked in patients with elevated BP prior to surgery (16 and 7 mm Hg decline in systolic and diastolic pressures respectively). Interestingly, Carson et al. [8] have recorded reductions of 10 and 9 mm Hg in systolic and diastolic BP, respectively, in obese normotensive patients 1 year after bariatric surgery. This lowering of BP in normotensive patients was also noted in our study and suggested that BP should be carefully measured at regular intervals postoperatively in order to avoid hypotension in all LRYGB patients and especially in those who are using antihypertensive medication. Clinicians both in the hospital and primary care setting should be alert to this phenomenon and not hesitate to reduce the dosage or withdraw antihypertensive medication after LRYGB.

This study demonstrates that LRYGB is associated with an early reduction in BP. This early impact on BP occurs before any significant weight loss is achieved thereby suggesting a hormonal mechanism may be involved for the changes observed. A similar phenomenon is seen in type 2 diabetics who undergo LRYGB and who very often get discharged home off of their insulin and oral hypoglycemics. Various neuroendocrine changes have been postulated to play a role in this. The gut peptide glucagon-like peptide 1 (GLP-1) has been implicated by some in the early improvement in glycemic control after LRYGB [21]. GLP-1 may also have a role in BP improvement via an effect on the autonomic nervous system [22] or through inducing natriuresis [23]. Another study has suggested that the obese state is associated with raised levels of plasma renin activity, aldosterone, and angiotensin-converting enzyme leading to sodium retention and that after LRYGB these abnormal hormone levels tend to normalize [24]. Other theories to explain the early reduction in BP include (a) reduced food and salt intake after LRYGB, (b) dumping syndrome after surgery causing avoidance of high-osmolarity substances such as salts, and (c) restoration of endothelial function.

This study has some important limitations. Firstly, measuring BP accurately can be problematic, cuff-size, digit-preference, observer bias, “office hypertension”, and lability of BP being a few of the more obvious difficulties [25]. Even if BP is measured using the best equipment and with appropriate time, the use of a single BP reading taken over a few seconds in a hospital setting to characterize the long-term behavior of a continuously variable phenomenon may be unrealistic. An attempt has been made in this study to minimize the effects of possible sources of bias. Firstly, each patient BP reading was taken after a 30-min rest period and performed by the same clinic nurse for each patient at each visit during our office hours 9 A.M.–5 P.M. The mean BP reading was calculated from three BP measurements using an electronic sphygmomanometer. We have therefore tried to reduce the effects of intra- and interobserver variation as well as intrasubject variation. However, we acknowledge that 24-h ambulatory BP measurements would have provided a more accurate BP measurement and would have also assessed the early effect of LRYGB on circadian BP variation, which has previously been shown to be altered in obesity and restored following LRYGB [12].

Another possible confounder is patient’s postoperative fluid status. It is possible that in the first week after LRYGB, patients are dehydrated secondary to surgery and reduced per oral intake of fluid and food. This, in turn, may impact their BP. Using the surrogate markers of serum urea to creatinine ratio and urine specific gravity for patients’ hydration status, we did not find any significant differences in their preoperative values and their values at postoperative week 1.

Another source of bias includes daily sodium intake postoperatively. Our standard postoperative week 1 diet consists of 1.5 l of liquid containing at least 60 g of protein daily. We do not regulate dietary sodium intake in our postoperative diet. It is possible that this is less than what patients were used to preoperatively which in turn may have an impact on BP postoperatively.

Our sample size was relatively small and 15 out of 100 subjects were lost to follow-up at year 1 after surgery. This effectively reduced our sample size to 85. Nevertheless, all BP changes compared to preoperative BP were statistically significant and in line with previously published data.

Our follow-up period was just 1 year and although a significant reduction in BP has been noted, Sjostrom et al. demonstrate in their landmark study that this may not persist [16]. The main criticism with their finding is that most of their patients underwent pure gastric restrictive procedures such as the vertical-banded gastroplasty, whose long-term efficacy has been questioned by some [26]. Others have shown that long-term (>1 year) BP reduction is seen after LRYGB [7]. In our study, all patients underwent LRYGB which appears to be a more effective operation for treating obese comorbidities [27]. Ideally, we would have liked to follow-up this cohort for 5 years or more to ascertain whether the early reduction in BP is maintained over a longer period of time.

Lastly, the cohort studied consists of a mixture of patients some hypertensive, others not, and those with hypertension, some treated, others not. This heterogeneity may cloud the amplitude of the effect of LRYGB on BP. However, using a nonhomogeneous group more closely represents daily practice in thousands of bariatric surgery centers worldwide and, in our opinion, makes our results even more noteworthy.

In conclusion, the results of this study demonstrate that LRYGB is associated with an early reduction in blood pressure and antihypertensive medication usage which is maintained at 1 year after surgery. This early impact on blood pressure occurs before any significant weight loss is achieved thereby suggesting a hormonal mechanism may be involved for the changes observed.

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