Effect of one anastomosis gastric bypass on liver function tests: A comparison between 150 cm and 200 cm biliopancreatic limbs

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Context: Some studies have shown that one anastomosis gastric bypass (OAGB) results in the derangement of liver function tests (LFTs). We wanted to study this in our patients.

Aims: The aims are to study the effect of OAGB on LFTs and to compare the effect of a biliopancreatic limb (BPL) of 150 cm (OAGB-150) to a BPL of 200 cm (OAGB-200).

Settings and Design: The study was a retrospective cohort study conducted at a university hospital.

Materials and Methods: Information was obtained from our prospectively maintained database and hospital’s computerised records.

Statistical Analysis: A $P < 0.05$ was regarded statistically significant; however, given the number of variables examined, findings should be regarded as exploratory.

Results: A total of 405 patients underwent an OAGB-200 ($n = 234$) or OAGB-150 ($n = 171$) in our unit between October 2012 and July 2018. There were significant improvements in gamma-glutamyl transpeptidase (GGT) levels at 1 and 2 years after OAGB-200 and significant worsening in the levels of alkaline phosphatase (ALP) and albumin at 1 and 2 years. There was a significant improvement in GGT levels at 1 and 2 years after OAGB-150 and in alanine transaminase levels at 1 year. There was a significant worsening in ALP and albumin levels at both follow-up points in this group. OAGB-150 group had a significantly lower bilirubin level at 1 year and significantly fewer abnormal ALP values at 2 years in comparison with OAGB-200 patients.

Conclusions: This exploratory study demonstrates the overall safety of OAGB with regard to its effect on LFTs, with no remarkable difference between OAGB-150 and OAGB-200.

Keywords: Bariatric surgery, biliopancreatic limb length, liver function tests, mini-gastric bypass, obesity surgery, omega-loop gastric bypass, one anastomosis gastric bypass, single anastomosis gastric bypass
INTRODUCTION

One anastomosis gastric bypass (OAGB) is gaining in popularity in most parts of the world and is widely regarded as a mainstream primary bariatric procedure with satisfactory outcomes.\(^1\) At the same time, this procedure has been the focus of many controversies almost from its inception.\(^2\)

One of the controversial aspects of this procedure is a significant risk of severe protein-calorie malnutrition in approximately 1.0% of the patients.\(^3\) It has resulted in liver failure and even deaths.\(^4\) The incidence of this complication appears to be related to the length of the biliopancreatic limb (BPL).\(^5\) This observation has led to the suggestion that the length of the BPL with an OAGB should not be longer than 150 cm, especially because a BPL of 150 cm delivers satisfactory weight loss outcomes that are similar to that with a BPL of 200 cm.\(^6\)

Although there have been some studies examining the impact of OAGB on the liver function tests (LFTs), there is no study in the scientific literature comparing the effect of OAGB-200 and OAGB-150 on LFTs. Eilenberg et al.\(^7\) have reported severe liver dysfunction after OAGB. Most of these patients had a BPL of >150 cm. Spivak et al.\(^8\) found from their national registry analysis that OAGB has a negative effect on liver enzymes at 1-year follow-up with a BPL of 200 cm. Similarly, Kruschitz et al.\(^9\) also found transient deterioration in several liver parameters in the 1st year after surgery with a BPL of 200 cm.

At the same time, Salman et al.\(^10\) reported not only substantial improvement in liver enzymes but also a significant improvement in histological features of non-alcoholic fatty liver disease 15 months after an OAGB performed with a BPL of 200 cm. In this study, non-alcoholic steatohepatitis disappeared in 42.0% of the patients and a significant regression in fibrosis was observed in 79.1% of the patients.

Aside from this controversy regarding the effect of an OAGB performed with a BPL of 200 cm on LFTs, there are virtually no data on the effect of an OAGB with a BPL of 150 cm on LFTs. The purpose of this pilot study was to separately study the effect of OAGB with a BPL of 200 cm or 150 cm on LFTs and also examine if there was any difference between the two limb lengths with regard to the effect on LFTs following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. We hypothesised that because of the associated weight loss, OAGB would improve the LFTs, not worsen them; and that OAGB with a BPL of 150 cm would deliver better outcomes than OAGB with 200 cm.

MATERIALS AND METHODS

Study design

We conducted a retrospective, cohort, pilot study to examine the effect of OAGB on LFTs in patients undergoing primary OAGB and then compared the outcomes in patients who had a BPL of 200 cm with those that had a BPL of 150 cm following the STROBE guidelines [Supplementary Data 1 provides the full STROBE compliance checklist]. The data were obtained from our database, hospital's computerised records, and case notes as and when necessary. Data were collected for 12 ± 4 months (1-year data) and 24 ± 4 months (2-year data) after the surgery.

Setting

The study was conducted in a large bariatric unit in a university-affiliated tertiary care hospital in the United Kingdom. All patients who underwent a primary OAGB in our unit between October 2012 and July 2018 were included in the study.

Participants

The study participants were patients who underwent a primary OAGB in our unit between October 2012 (when we performed our first OAGB procedure) and July 2018 (to allow for a follow-up of 24 months for all patients). We then separated these patients into two groups. The first group consisted of patients who underwent an OAGB with a BPL of 200 cm (OAGB-200) and the second group included patients who underwent an OAGB with a BPL of 150 cm (OAGB-150). Patients undergoing a revisional OAGB (conversion from a previous gastric band or sleeve) and patients who underwent an OAGB with a BPL other than 200 cm or 150 cm (n = 6) were excluded from the analysis. The technique of the procedure and the post-operative protocol have been described previously.\(^11\)

Variables examined

We compared the demographic characteristics, BPL, weight loss and LFTs between both groups. The normal values for various LFTs in our hospital laboratory are as follows: bilirubin - 0–21 µmol/L; gamma-glutamyl transpeptidase (GGT) - 0–70 IU/L; aspartate transaminase (AST) - 0–40 IU/L; alanine transaminase (ALT) - 0–40 IU/L; alkaline phosphatase (ALP) - 30–130 IU/L; and albumin - 35–50 g/L. We also evaluated weight loss as that can affect LFTs. Potential confounders that were not examined were alcohol intake, use of other drugs that would impact LFTs and the presence or absence of gall stones.
Data source/bias
Data were collected from our hospital’s computerised records and patient case notes as and when necessary. It is our routine practice to check pre-operative and post-operative LFTs at all follow-up points for all patients. This would minimise bias. There is no difference in data collection or follow-up protocols in the OAGB200 and OAGB150 groups. The only difference was that surgeons would have chosen a different limb length. The potential discrepancy in the measurement of small bowel lengths amongst surgeons is another source of bias but that would apply equally to both the groups. The concept of precise length cannot be applied to a stretchable human organ, like small bowel. Patients are followed up in our unit by our dieters who do not know the limb lengths used, and because the change is an evolution in the practice of surgeons, most patients would not be aware of the specific BPL used for them either.

Study size
Given that a previous study[14] on OAGB-200 has shown significant impairment of LFTs with far fewer patients ($n = 25$), we deemed that our much larger sample size would provide us with adequate numbers to study this limb length. However, there are no published data on the effect of OAGB-150 on LFTs. This prevented us from undertaking a formal sample size calculation for this retrospective, cohort, pilot study. We included the maximum number of patients possible to increase confidence in our findings.

Statistical analysis
Means were compared using unpaired $t$-test, and frequencies were compared using Fisher’s exact test. A $P < 0.05$ was regarded statistically significant. The Microsoft Excel® and the GraphPad® software (Graphpad Holdings, LLC, California corporation. San Diego, California,USA) were used. We used the mean value substitution method to deal with the missing data.

RESULTS
A total of 405 patients underwent OAGB in our unit between October 2012 and July 2018 with a BPL of either 200 cm or 150 cm. Weight loss data were available for 378 (93.3%) patients at 1-year follow-up and 338 (83.4%) patients at 2-year follow-up. LFTs were available for 374 (92.3%) patients at 1-year follow-up and 286 (70.6%) patients at 2-year follow-up. Other patients were lost to follow-up. The availability of LFTs at the 2-year mark may have further been affected by the coronavirus disease 2019 pandemic.

The mean age of the patients was $46 \pm 10.98$ years and 276 (67.3%) were females. The mean pre-operative weight and the body mass index (BMI) were $139 \pm 29.96$ kg and $49 \pm 8.14$ kg/m$^2$, respectively. The mean weight loss in kg, percentage excess weight loss (%EWL) and percentage total weight loss (%TWL) at 1 year were $49 \pm 18.12$ kg, $75\% \pm 21.2\%$ and $35.0\%$, respectively. At 2-year follow-up, the respective numbers were $49 \pm 18.78$ kg, $76\% \pm 20.57\%$ and $35\% \pm 9.36\%$.

There were 234 patients in the OAGB-200 group. The mean age of the patients in this group was $46 \pm 11.06$ years with 154 (65.8%) females. The mean weight loss, %EWL and %TWL at 1 year was $52 \pm 18.74$ kg, $76\% \pm 21.77\%$ and $36\% \pm 9.15\%$, respectively. At 2 years, these numbers were $51 \pm 19.15$ kg, $76\% \pm 20.10\%$ and $36\% \pm 9.18\%$, respectively. Table 1 compares the LFTs at 1 and 2 years of follow-up with the pre-operative values. There was a significant improvement in GGT at 1 and 2 years of follow-up, whereas significant worsening in the levels of ALP and albumin at 1 and 2 years of follow-up compared to pre-operative levels.

There were 171 patients in the OAGB-150 group. The mean age of these patients was $46 \pm 10.92$ years with 121 (70.7%) females. The mean weight loss, %EWL and %TWL at 1 year and 2 years of follow-up were $45 \pm 16.42$ kg, $73\% \pm 20.34\%$ and $33\% \pm 8.45\%$, respectively, and $46 \pm 17.52$ kg, $75\% \pm 21.3\%$ and $34\% \pm 9.48\%$, respectively. Table 2 compares the LFTs at 1 and 2 years of follow-up with the pre-operative values in this group. There was a significant improvement in GGT levels at 1 and 2 years after surgery and in the ALT levels at 1-year follow-up. There was a significant worsening in the ALP and albumin levels at 1 and 2 years after the surgery.

Table 3 compares the basic demographics and weight parameters at different time intervals between the two groups. OAGB-200 group had a significantly higher pre-operative weight and BMI. There was no significant difference in %EWL between the two groups at either 1 or 2 years of follow-up. Absolute weight loss was significantly higher in the OAGB-200 group at both 1 and 2 years of follow-up. The difference in %TWL was only significant at a 1-year follow-up.

Table 4 compares the liver function parameters between OAGB-200 and OAGB-150 groups pre-operatively, at 1-year follow-up, and at 2-year follow-up. OAGB-150 group had a significantly lower bilirubin level at 1 year and significantly fewer abnormal ALP levels at 2 years.

DISCUSSION
Protein-calorie malnutrition with or without liver failure has been reported after OAGB[16-19] and seems to be directly
related to the length of the BPL. [8] Rutledge, [5] in his original series of 2410 patients, reported 'excessive weight loss with malnutrition' in 1.1% of patients. Lee et al. [20] in their 15-year experience with OAGB, reported revision for malnutrition in 2.5% of patients.

There are conflicting reports on the effect of OAGB-200 on LFTs. [13-15] Kruschitz et al. [14] only analysed 25 OAGB patients and found ALT levels to be significantly higher in the OAGB group at 1-year follow-up. In contrast we found ALT levels to be significantly lower in OAGB 150 group at 1 year. They also noticed a rise in AST levels, a finding we did not observe in either of our patient groups. However, they also noticed a non-significant improvement in GGT levels in their patients. In our study, the improvement was significant in levels of GGT at 1 and 2 years in both OAGB-200 and OAGB-150 groups.

In the article by Spivak et al., [13] authors only reported on 469 patients who had 1-year data available out of a total of 715 patients. This was, however, an analysis of national registry data which can often be of poor quality and make the comparison of laboratory values more cumbersome. Ours is a single-centre study with a similar number of

Table 1: Liver function tests in the one anastomosis gastric bypass-200 group at 1 and 2 years follow-up compared to the pre-operative values

|                      | Pre-operative | 1-year | 2-year | 95% CI | 95% CI |
|----------------------|---------------|--------|--------|--------|--------|
| Mean bilirubin (mg/dL) | 9.08±4.68     | 10.76±1.6 | 8.37±5.04 | 0.08261 | −0.28–1.69 |
| Abnormal bilirubin (%) | 3 (1.35%)     | 8 (3.73) | NA     | 4 (2.53) | 0.4562 NA |
| Mean GGT (U/L)       | 37.99±29.05   | 27.33±32.32 | 26.28±33.0 | 0.0033* | 5.44–17.98 |
| Abnormal GGT (%)     | 38 (17.04)    | 21 (9.85) | NA     | 13 (8.17) | 0.0142* NA |
| Mean AST (U/L)       | 23.63±11.46   | 28.54±12.2 | 25.34±10.26 | 0.1661 | −4.13–0.71 |
| Abnormal AST (%)     | 14 (6.76)     | 15 (7.5) | NA     | 10 (7.75) | 0.8282 NA |
| Mean ALT (U/L)       | 30.34±27.52   | 30.63±45.60 | 28.11±21.41 | 0.3954 | −2.92–7.37 |
| Abnormal ALT (%)     | 35 (16.59)    | 27 (12.79) | 20 (12.65) | 0.4608 NA |
| Mean ALP (U/L)       | 80.50±24.69   | 90.14±28.57 | 90.13±32.81 | 0.0012* | −15.41–3.84 |
| Abnormal ALP (%)     | 8 (3.57)      | 16 (7.47) | NA     | 13 (8.22) | 0.0672 NA |
| Mean albumin (g/dL)  | 45.75±3.15    | 43.2±3.53 | <0.001* | 1.92±3.178 | 0.0001* 1.67–3.046 |
| Abnormal albumin (%) | 0 (0)         | 3 (1.39) | 4 (2.53) | 0.0289* NA |

*Significant difference. GGT: Gamma glutamyl-transpeptidase, AST: Aspartate transaminase, ALT: Alanine transaminase, ALP: Alkaline phosphatase

Table 2: Liver function tests in the one anastomosis gastric bypass-150 group at 1 and 2 years of follow-up compared to the pre-operative values

|                      | Pre-operative | 1-year | 2-year | 95% CI | 95% CI |
|----------------------|---------------|--------|--------|--------|--------|
| Mean bilirubin (mg/dL) | 8.18±5.62     | 8.52±4.38 | 8.22±5.28 | 0.9505 | −1.30–1.22 |
| Abnormal bilirubin (%) | 3 (1.79%)     | 3 (1.85%) | NA     | 3 (2.34%) | 1.0000 NA |
| GGT (U/L)            | 37.79±30.49   | 24.33±37.41 | 22.69±23.04 | 0.0001* | NA |
| Abnormal GGT (%)     | 27 (16.16)    | 9 (5.48%) | NA     | 7 (5.38%) | 0.0052* NA |
| AST (U/L)            | 24.45±12.65   | 24.24±20.41 | 24.83±10.39 | 0.8003 | −3.31–2.56 |
| Abnormal AST (%)     | 13 (8.28%)    | 10 (6.62%) | NA     | 6 (5.76%) | 0.6274 NA |
| ALT (U/L)            | 31.63±22.06   | 24.63±13.77 | 27.36±16.08 | 0.0639 | −0.25–8.79 |
| Abnormal ALT (%)     | 31 (18.52%)   | 16 (9.87%) | NA     | 17 (13.07%) | 0.2659 NA |
| ALP (U/L)            | 75.69±19.97   | 89.07±26.8 | 83.79±17.2 | 0.0009* | −12.85–3.35 |
| Abnormal ALP (%)     | 2 (1.19%)     | 7 (4.34%) | NA     | 2 (1.53%) | 1.0000 NA |
| Albumin (g/dL)       | 45.13±2.87    | 43.5±3.14 | 0.0001* | 0.93±2.224 | 0.0001* 0.73–1.164 |
| Abnormal albumin (%) | 1 (0.58%)     | 2 (1.21%) | 3 (2.29%) | 0.3208 NA |

*Significant difference. GGT: Gamma glutamyl-transpeptidase; AST: Aspartate transaminase; ALT: Alanine transaminase; ALP: Alkaline phosphatase

Table 3: Comparison of basic demographics and weight parameters between one anastomosis gastric bypass-200 and one anastomosis gastric bypass-150 groups

| Categories                | OAGB-200              | OAGB-150              | P       | 95% CI   |
|---------------------------|-----------------------|-----------------------|---------|----------|
| n                         | 234                   | 171                   | 2.60–1.74 |
| Mean age                  | 46.01±11.07           | 46.44±10.92           | 0.6977   |
| Females (%)               | 154 (65.8%)           | 121 (70.7%)           | 1.836–13.601 |
| Pre-operative BMI         | 142.18±32.97          | 134.47±24.68          | 0.0102* | 0.548–3.734 |
| Weight loss (kg) at 1 year| 51.86±18.74           | 45.33±16.42           | 0.0004* | 2.913–10.157 |
| %EWL at 1 year            | 76.23±21.77           | 72.70±20.34           | 0.1077   | 0.776–7.847 |
| %TWL at 1 year            | 36.32±9.15            | 33.30±8.45            | 0.0011* | 1.212–4.821 |
| Weight loss (kg) at 2 years| 51.19±19.15           | 45.63±17.52           | 0.0079* | 1.471–9.666 |
| %EWL at 2 years           | 76.46±20.10           | 75.02±21.35           | 0.5335   | 3.112–5.999 |
| %TWL at 2 years           | 36.15±9.19            | 34.12±9.49            | 0.0530   | 0.026–4.091 |

*Significant difference. EWL: Excess weight loss, TWL: Total weight loss, BMI: Body mass index
patients and longer follow-up. Similar to these authors, we also found a significant increase in ALP levels in both OAGB-200 and OAGB-150 groups in our study at both 1 and 2 years of follow-up. However, we were not able to confirm significant deterioration in ALT and AST levels and an increase in the number of abnormal values seen by these authors. In contrast, for OAGB-150 patients, we observed a decrease in levels of both AST and ALT at 1 year; the decrease was significant for ALT levels.

It is difficult to understand the differences in findings between these studies and that of ours with OAGB-200 because both these groups of Spivak *et al*. and Kruschitz *et al.*[13,14] also used a BPL of 200 cm for all of their patients. One possible explanation of the different findings can be the potential for differences in the measurement of the small bowel. That is why our group has previously argued that any recommendation for limb lengths for gastric bypass procedures should be able to absorb some errors in measurement.[21]

In our opinion, this makes OAGB-150 a particularly attractive choice as it is likely to offer a bigger margin of error in measurement and hence higher safety. We have previously argued that an OAGB-150 would reduce the rates of protein-calorie malnutrition with this procedure without significantly compromising the weight loss outcomes.[8,9,11] There are, however, no published data in the literature on the effect of OAGB-150 on LFTs. We found significant improvement in GGT levels at 1 and 2 years after surgery and in ALT levels at 1-year follow-up. Similar to these authors, we also found a significant increase in ALP levels in both OAGB-200 and OAGB-150 groups in our study at both 1 and 2 years of follow-up. However, we were not able to confirm significant deterioration in ALT and AST levels and an increase in the number of abnormal values seen by these authors. In contrast, for OAGB-150 patients, we observed a decrease in levels of both AST and ALT at 1 year; the decrease was significant for ALT levels.

| Categories                     | OAGB-200          | OAGB-150          | P     | 95% CI          |
|-------------------------------|-------------------|-------------------|-------|-----------------|
| Pre-operative mean bilirubin  | 9.08±4.68         | 8.18±5.62         | 0.855 | −0.13–1.92      |
| 1-year mean bilirubin         | 10.09±7.61        | 8.52±4.38         | 0.0188* | 0.26–2.88      |
| 2-year mean bilirubin         | 8.37±5.04         | 8.22±5.28         | 0.8081 | −1.05–1.35      |
| Pre-operative abnormal bilirubin | 3 (1.35)         | 3 (1.79%)         | 1.0000 | NA              |
| 1-year abnormal bilirubin     | 8 (3.73)          | 3 (1.85%)         | 0.3632 | NA              |
| 2-year abnormal bilirubin     | 4 (2.53)          | 3 (2.34%)         | 1.0000 | NA              |
| Pre-operative mean GGT        | 37.99±29.05       | 37.79±30.49       | 0.9462 | −5.74–6.15      |
| 1-year mean GGT               | 27.33±32.32       | 24.33±37.41       | 0.4038 | −4.06–10.07     |
| 2-year mean GGT               | 26.28±33.01       | 22.69±23.04       | 0.2952 | −3.15–10.33     |
| Pre-operative abnormal GGT    | 38 (17.04)        | 27 (16.16)        | 0.8911 | NA              |
| 1-year abnormal GGT           | 21 (9.85)         | 9 (5.48)          | 0.1294 | NA              |
| 2-year abnormal GGT           | 13 (6.87)         | 7 (5.38)          | 0.4856 | NA              |
| Pre-operative mean AST        | 23.63±11.46       | 24.45±12.65       | 0.5170 | −3.31–1.67      |
| 1-year mean AST               | 28.50±4.22        | 24.24±20.41       | 0.2418 | −2.88–11.40     |
| 2-year mean AST               | 25.34±10.26       | 24.83±10.39       | 0.7067 | −2.16–3.19      |
| Pre-operative abnormal AST    | 14 (6.76)         | 13 (8.28%)        | 0.6872 | NA              |
| 1-year abnormal AST           | 15 (7.5)          | 10 (6.62%)        | 0.8357 | NA              |
| 2-year abnormal AST           | 10 (7.75)         | 6 (5.76%)         | 0.6112 | NA              |
| Pre-operative mean ALT        | 30.34±27.52       | 31.63±22.06       | 0.6163 | −6.37–3.78      |
| 1-year mean ALT               | 30.63±45.60       | 24.63±13.77       | 0.1052 | −1.27–13.27     |
| 2-year mean ALT               | 28.11±21.41       | 27.36±16.08       | 0.7408 | −3.72–5.22      |
| Pre-operative abnormal ALT    | 35 (15.69)        | 31 (18.52%)       | 0.4960 | NA              |
| Pre-operative abnormal AST    | 27 (12.79)        | 16 (9.87)         | 0.4170 | NA              |
| 1-year abnormal ALT           | 20 (12.65)        | 17 (13.07)        | 1.0000 | NA              |
| Pre-operative mean ALP        | 80.50±24.69       | 75.69±19.97       | 0.0390* | 0.24–9.37     |
| 1-year mean ALP               | 90.14±28.57       | 89.07±26.81       | 0.7097 | −4.61–6.76      |
| 2-year mean ALP               | 90.13±32.81       | 83.79±21.72       | 0.0595 | −0.26–12.92     |
| Pre-operative abnormal ALP    | 8 (3.57)          | 2 (1.19)          | 0.1990 | NA              |
| 1-year abnormal ALP           | 16 (7.47)         | 7 (4.34)          | 0.2779 | NA              |
| 2-year abnormal ALP           | 13 (8.22)         | 2 (1.53)          | 0.0143 | NA              |
| Pre-operative mean albumin    | 45.75±5.35        | 45.13±2.87        | 0.0472* | 0.008–1.222   |
| 1-year mean albumin           | 43.20±3.53        | 43.55±3.14        | 0.3051 | −1.044–0.328    |
| 2-year mean albumin           | 43.39±3.65        | 43.68±3.43        | 0.4826 | −1.122–0.531    |
| Pre-operative abnormal albumin| 0 (0)             | 1 (0.58)          | 0.4326 | NA              |
| Pre-operative normal AST      | 1.0000            |                  |        |                 |
| 1-year abnormal albumin       | 3 (1.39)          | 2 (1.21)          | 1.0000 | NA              |
| 2-year abnormal albumin       | 4 (2.53)          | 3 (2.29)          | 1.0000 | NA              |

*Significant difference. GGT: Gamma-glutamyl transpeptidase, AST: Aspartate transaminase, ALT: Alanine transaminase, ALP: Alkaline phosphatase

Table 4: Comparison of liver parameters between one anastomosis gastric bypass-200 and one anastomosis gastric bypass-150 groups
follow-up. There was a significant worsening in ALP and albumin levels at 1 and 2 years after surgery. Most of these findings are similar to the OAGB-200 group except that the improvement in ALT at 1 year was not observed with OAGB-200. On comparing the two groups with each other, we found significantly lower bilirubin with OAGB-150 at 1 year and significantly fewer abnormal ALP levels at 2 years. There was no significant difference in other liver parameters between the two limb lengths. In general, it appears that LFT outcomes are marginally better with OAGB-150. Once again, comparative data for two different BPL lengths of OAGB do not exist in the literature.

Another important factor worth highlighting here is that the effect on liver parameters is different from the problem of liver failure seen in some individuals, often in conjunction with protein-calorie malnutrition. It is entirely possible for a procedure to lead to liver failure due to protein-calorie malnutrition (or some other cause) in some individuals but without a significant worsening of liver functions in the majority. At the same time, if a procedure is leading to deterioration of the liver functions in a large number of patients, this can be a significant issue in itself. Reassuringly, in both OAGB 200 and OAGB 150 groups in our study, there was no significant increase in the number of abnormal values for any of the tests examined except serum albumin at 2 years in the OAGB-200 group.

Serum albumin levels can be an indicator of synthetic liver functions. At the same time, it can also be related to the intake and absorption of proteins. We noticed a small but significant decline in albumin levels in both groups at 1 and 2 years of follow-up. It is worth noting here that we do not recommend any artificial protein supplements to our patients after surgery though patients are encouraged to follow a high protein diet. We are, therefore, unsure if the slight (though statistically significant) fall in albumin levels without any significant increase in the number of abnormal values is down to liver, protein intake, or indeed the reduced absorption of proteins. Interestingly, Kruschitz et al. did not observe any changes in albumin levels. However, they did not provide the exact albumin levels. It is further unclear if their patients were given artificial protein supplements.

At the same time, there is only one study reporting on liver histology after OAGB and only two other studies examining LFTs after OAGB. Significantly, all of these studies are on OAGB-200, and there are no published data on LFTs after OAGB-150 and no comparative data evaluating the differential effect of these two BPL lengths on LFTs after OAGB. Moreover, LFTs can be affected by several other factors such as gall stones, drugs and alcohol. Our study is not able to comment on these factors. At the same time, it is not a crucial limitation as we are not reporting deterioration in liver parameters in a large number of patients. Finally, our statistical analyses should be regarded as exploratory in nature as we have examined a large number of variables. Future focussed studies need to examine them separately.

**Generalisability**
Variation in measurements of small bowel length amongst surgeons means that results may vary from centre to centre even if they use the same BPL while performing the OAGB. This should encourage surgeons to examine the shortest possible effective BPL for this procedure which can overcome these variations in measurement. The presence or absence of gall stones, the use of other pharmacological agents that can affect LFTs and alcohol intake are other significant confounding variables that we have not been able to control for.

**CONCLUSIONS**
This study demonstrates the overall safety of OAGB with regard to its effect on LFTs with no remarkable difference between OAGB-150 and OAGB-200. Some liver parameters were actually seen to improve with OAGB. There was a slight, significant decline in albumin levels with both OAGB-150 and OAGB-200 at 1 and 2 years of follow-up after surgery. Findings of this exploratory study need confirmation in larger, focussed prospective studies.

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**Conflicts of interest**
There are no conflicts of interest.

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Supplementary Data 1: STROBE Statement – Checklist

| Items | Item number | Recommendation |
|-------|-------------|----------------|
| Title and abstract | 1 | (a) Indicate the study’s design with a commonly used term in the title or the abstract | ✓ |
| (b) Provide in the abstract an informative and balanced summary of what was done and what was found | ✓ |
| Introduction | 2 | Explain the scientific background and rationale for the investigation being reported | ✓ |
| Background/ rationale | 3 | State specific objectives, including any pre-specified hypotheses | ✓ |
| Objectives | | | |
| Methods | 4 | Present key elements of study design early in the paper | ✓ |
| Study design | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up and data collection | ✓ |
| Setting | | | |
| Participants | 6 | (a) Cohort study – Give the eligibility criteria and the sources and methods of selection of participants. Describe methods of follow-up | ✓ |
| Case–control study – Give the eligibility criteria and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls | |
| Cross-sectional study – Give the eligibility criteria, and the sources and methods of selection of participants | |
| (b) Cohort study – For matched studies, give matching criteria and number of exposed and unexposed | |
| Case–control study – For matched studies, give matching criteria and the number of controls per case | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders and effect modifiers. Give diagnostic criteria, if applicable | ✓ |
| Data sources/measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). | ✓ |
| Bias | 9 | Describe any efforts to address potential sources of bias | ✓ |
| Study size | 10 | Explain how the study size was arrived at | ✓ |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | ✓ |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding | ✓ |
| (b) Describe any methods used to examine subgroups and interactions | ✓ |
| (c) Explain how missing data were addressed | ✓ |
| (d) Cohort study – If applicable, explain how loss to follow-up was addressed | |
| Case–control study – If applicable, explain how matching of cases and controls was addressed | |
| Cross-sectional study – If applicable, describe analytical methods taking account of sampling strategy | |
| (e) Describe any sensitivity analyses | | NA |
| Results | 13* | (a) Report numbers of individuals at each stage of study – for example, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up and analysed | ✓ |
| (b) Give reasons for non-participation at each stage | ✓ |
| (c) Consider use of a flow diagram | ✓ |
| Participants | | | |
| Descriptive data | 14* | (a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders | ✓ |
| (b) Indicate number of participants with missing data for each variable of interest | ✓ |
| (c) Cohort study – Summarise follow-up time (e.g. average and total amount) | NA |
| Outcome data | 15* | Cohort study – Report numbers of outcome events or summary measures over time | ✓ |
| Case–control study – Report numbers in each exposure category, or summary measures of exposure | |
| Cross-sectional study – Report numbers of outcome events or summary measures | NA |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included | ✓ |
| (b) Report category boundaries when continuous variables were categorised | |
| (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| Other analyses | 17 | Report other analyses done – e.g., analyses of subgroups and interactions and sensitivity analyses | ✓ |
| Discussion | | | |
| Key results | 18 | Summarise key results with reference to study objectives | ✓ |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | ✓ |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | ✓ |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | ✓ |
| Other information | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | |

*Significance set at $P$ value <0.05