Male gender is an independent risk factor for patients undergoing laparoscopic sleeve gastrectomy or Roux-en-Y gastric bypass: an MBSAQIP® database analysis

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Abstract

Background Male patients undergoing bariatric surgery have (historically) been considered higher risk than females. The aim of this study was to examine the disparity between genders undergoing laparoscopic sleeve gastrectomy (SG) and laparoscopic Roux-en-Y gastric bypass (RYGB) procedures and assess gender as an independent risk factor.

Methods The MBSAQIP® Data Registry Participant User Files for 2015–2017 was reviewed for patients having primary SG and RYGB. Patients were divided into groups based on gender and procedure. Variables for major complications were grouped together, including but not limited to PE, stroke, and MI. Univariate and propensity matching analyses were performed.

Results Of 429,664 cases, 20.58% were male. Univariate analysis demonstrated males were older (46.48 ± 11.96 vs. 43.71 ± 11.89 years, \( p < 0.0001 \)), had higher BMI (46.58 ± 8.46 vs. 45.05 ± 7.75 kg/m², \( p < 0.0001 \)), and had higher incidence of comorbidities. Males had higher rates of major complications (1.72 vs. 1.05%; \( p < 0.0001 \)) and 30-day mortality (0.18 vs. 0.07%, \( p < 0.0001 \)). Significance was maintained after subgroup analysis of SG and RYGB. Propensity matched analysis demonstrated male gender was an independent risk factor for RYGB and SG, major complications [2.21 vs. 1.7%, \( p < 0.0001 \) (RYGB), 1.12 vs. 0.89%, \( p < 0.0001 \) (SG)], and mortality [0.23 vs. 0.12%, \( p < 0.0001 \) (RYGB), 0.10 vs. 0.05%; \( p < 0.0001 \) (SG)].

Conclusion Males continue to represent a disproportionately small percentage of bariatric surgery patients despite having no difference in obesity rates compared to females. Male gender is an independent risk factor for major post-operative complications and 30-day mortality, even after controlling for comorbidities.

Keywords Bariatric surgery · Sleeve gastrectomy · Roux-en-Y gastric bypass · Gender · MBSAQIP

The incidence and impact of obesity on public health is a significant global concern, and has reached epidemic proportions in the United States. According to the Center for Disease Control (CDC), obesity prevalence among adults increased from 30.5 to 39.8% between 2000 and 2016 [1]. Historically, the incidence of obesity among females has been higher than that of males. However, over the last two decades the obesity gender gap has continued to narrow in the United States [1], with the most recent CDC data (2015–2016) reporting no significant gender difference for obesity prevalence [2]. Despite these changes in obesity demographics, males continue to represent a significantly smaller proportion of obese patients undergoing bariatric surgery (analyses of the Bariatrics Outcomes Longitudinal Database and ACS-NSQIP databases report 79% female...
Roux-en-Y gastric bypass (RYGB) procedure. For patients undergoing either a sleeve gastrectomy (SG) or
to assess the impact of gender as an independent risk factor
in the United States utilizing the MBSAQIP® database, and
between genders for patients undergoing bariatric surgery
adjusted for during multi-variant analysis.

Included in the NIS database, and therefore could not be
ever, it should be noted in these studies that BMI data is not
mechanisms [7]). The PUFs are available to all participat-
MBSAQIP® data registry is maintained by internal audit
and 2016 (data consistency and reliability within the
Files (PUF) gathered from more than 800 academic and
Data was accessed from the MBSAQIP® Participant Use
Statistical analysis was performed using R Software
package. Chi square test for independence or paired
were utilized for categorical and continuous data
as appropriate. Due to the large number of patients in the
MBSAQIP® database, a p value < 0.0001 was used to iden-
ify statistically significant differences of clinical relevance.

Methods

Institutional assurances

The Carolinas Medical Center Institutional Review Board
certified that retrospective analyses of public, anonymized
data sets (including the MBSAQIP® data registry) are
deemed exempt from review.

Data source

Data was accessed from the MBSAQIP® Participant Use
Files (PUF) gathered from more than 800 academic and
community MBSAQIP® accredited centers between 2015
and 2016 (data consistency and reliability within the
MBSAQIP® data registry is maintained by internal audit
mechanisms [7]). The PUFs are available to all participat-
ing centers (upon request) and contain deidentified data that
includes preoperative risk factors, intraoperative variables,
and 30-day postoperative complications and mortality.

The MBSAQIP® data registry was queried for patients
(18 years or older) undergoing laparoscopic RYGB or SG
based on CPT codes 43644 (RYGB) and 43755 (SG). Exclu-
sion criteria included patients with emergent, endo-therapy,
gastric plication, revisional and balloon procedures, and
cases with incomplete data. Major complications were
defined as acute renal failure, cardiac arrest, coma > 24 h,
cerebrovascular accident (CVA), myocardial infarction (MI),
post-operative ventilator, progressive renal insufficiency,
pulmonary embolism (PE), sepsis, septic shock, unplanned
intubation, venous thrombo-embolism (VTE), organ space
surgical site infection (SSI), and unplanned intensive care
unit (ICU) admission. Minor complications were defined as
post-operative SSI, urinary tract infection (UTI), wound
disruption, and incisional SSI.

A univariate analysis was performed on patient demo-
graphics, comorbid risk factors, procedure details and out-
comes for RYGB and SG. In a secondary set of analyses,
propensity scores were calculated for patient demographics
(age, BMI, race) and comorbid risk factors (gastroesopha-
geal reflux disease (GERD), mobility status, hypertension
requiring medication, cardiac conditions, hyperlipidemia,
history of deep venous thromboembolism (VTE), venous
stasis, anticoagulation therapy, renal conditions, previous
foregut surgery, diabetes requiring insulin, smoking status,
functional independence, oxygen usage, obstructive sleep
apnea, and chronic steroid usage). Subjects were matched
using a generalized boosted regression algorithm, an
approach that provides effective weighting when utilizing
a large number of matching covariates [8]. To assess the
quality of the matching algorithm, distributions of covari-
ates between male and female groups for RYGB and SG
were assessed by absolute mean differences between groups
(Figs. 1 and 2). Weights were applied to each subject and
univariate analyses were repeated [9].

Statistical analysis

Statistical analysis was performed using R Software
(V3.4.1). Propensity score weights were generated using the
twang package. Chi square test for independence or paired
r-tests were utilized for categorical and continuous data
as appropriate. Due to the large number of patients in the
MBSAQIP® database, a p value < 0.0001 was used to iden-
tify statistically significant differences of clinical relevance.

Results

Using the complete MBSAQIP® data set 555,239 cases
were identified (2015–2017) from which 429,664 cases of
primary RYGB and SG remained after exclusion criteria
were applied. This patient population was then subdivided
by gender resulting in 341,238 females (79.42%) and 88,426
males (20.58%), the patient demographics for which are
detailed in Table 1. Performing a univariate analysis demonstr-
ated males were slightly older that females (46.48 ± 11.96
vs. 43.71 ± 11.89 years, \( p < 0.0001 \), had clinically similar BMI (46.58 ± 8.46 vs. 45.05 ± 7.75 kg/m², \( p < 0.0001 \)), and had a significantly higher incidence of comorbidities compared to females (Table 1). Specifically, males had a higher incidence of cardiac history (MI or cardiac procedure) compared to females (7.14 vs. 2.17%, \( p < 0.0001 \)), HTN (63.12% vs. 44.73%, \( p < 0.0001 \)), renal insufficiency (1.72 vs. 0.55%, \( p < 0.0001 \)), DM on insulin (13.66% vs. 7.32%, \( p < 0.0001 \)), COPD (2.50% vs. 1.58%, \( p < 0.0001 \)), and OSA (59.02 vs. 32.69%, \( p < 0.0001 \)). These differences remained statistically different after performing a subgroup analysis of LRYGB and SG (Table 1).

A similar univariate analysis of 30-day outcomes was then performed (Table 2). This analysis demonstrated males exhibited higher rates of major complications compared to females (1.72 vs. 1.05%, \( p < 0.0001 \)), 30-day mortality (0.18 vs. 0.07%, \( p < 0.0001 \)), and bleeding (0.15 vs. 0.08%, \( p < 0.0001 \)). These differences remained statistically different after performing a subgroup analysis of RYGB and SG (Table 2), with the exception that males had higher leak rates than females overall (0.14 vs. 0.12%, \( p = 0.049 \)), but this significance was lost during subgroup analysis of RYGB and SG (Table 2).

Propensity score matching was performed for the 341,238 females against the 88,426 males and patient demographics are presented in Table 3. Using this approach excellent matching was achieved as indicated by the lack of significant difference between age, BMI, and preoperative comorbidities (but not COPD) between were no longer significantly different between males and females (Table 3). The propensity matched outcomes within procedure subgroups (RYGB and SG) are presented in Table 4. This approach demonstrated that in both RYGB and SG, males maintained higher rates of 30-day major complications [2.21 vs. 1.7%; \( p < 0.0001 \) (RYGB), 1.12 vs. 0.89%; \( p < 0.0001 \) (SG)] and 30-day mortality [0.23 vs. 0.12%; \( p < 0.0001 \) (RYGB), 0.10 vs. 0.05%; \( p < 0.0001 \) (SG)] compared to females. Postoperative bleeding rates remained higher in males [0.32 vs. 0.23%, \( p = 0.0024 \) (RYGB), 0.06 vs. 0.03%, \( p = 0.0005 \) (SG)], but was no longer highly significant (\( p < 0.0001 \)). Leak rates maintained no significant difference between males and females in both RYGB and SG. Of note though,
female patients did have higher 30-day readmission rates compared to males in both RYGB and SG groups [6.03 vs. 4.97%; p < 0.0001 (RYGB) and 3.11 vs. 2.60%, p < 0.0001 (SG)].

**Discussion**

To our knowledge this is the first MBSAQIP database analysis evaluating morbidity and mortality in male and female patients after laparoscopic SG or laparoscopic RYGB. Based on approximate parity of the incidence of obesity in the United States [2], our analysis demonstrate females continue to represent a disproportionately high number of patients undergoing either SG or RYGB procedures. In addition, males tend to have a slightly higher BMI and are older when they undergo bariatric procedures compared to than females. Clinically, males also had a significantly higher incidence of comorbidities than females that was also reflected in higher 30-day morbidity and mortality rates following either SG or RYGB. This disparity between males and females remained true even after controlling for pre-operative comorbidities with propensity matching, leading us to the conclusion that male gender is an independent risk factor in patients undergoing SG or RYGB. Prior to propensity matching, cardiac disease had one of the largest gender gaps in the preoperative patient demographics with males having almost 4 times the incidence compared to females. In addition, males had higher post-operative MI and other cardiac complications. This increased cardiac risk was controlled for during propensity matching and resulting in lower and similar cardiac complication rates between genders and a significant reduction in mortality and major complication rates in males. We can translate this into clinical practice by trying to identify as much cardiac disease as possible and optimize these conditions as much as possible preoperatively. Since Males had more cardiac disease before surgery and more cardiac complications after, these patients would benefit the most from having a lower threshold to perform a thorough cardiac assessment.

The MBSAQIP data base does not allow us to determine the preoperative workups of each center, however its it likely that some patients made it to surgery with undiagnosed cardiac disease which may be a contributing factor as to why males maintained a higher 30-day mortality rate despite controlling for cardiac disease during propensity matching.
Table 1  Patient characteristics

|                  | Gastric bypass | Sleeve gastrectomy | Total |        |
|------------------|----------------|---------------------|-------|--------|
|                  | Male           | Female              | p value | Male | Female | p value |
| N value          | 23357          | 94242               |        | 65069 | 24696   |        |
| Frequency (%)    | 19.86%         | 80.14%              |        | 20.85% | 79.15%  |        |
| Mean age ± SD    | 47.51 (11.72)  | 44.36 (11.82)       | < 0.0001** | 46.11 (12.03) | 43.46 (11.91) | < 0.0001** |
| Mean BMI at surgery ± SD | 46.89 (8.46) | 45.94 (7.91) | < 0.0001** | 46.46 (8.45) | 44.72 (7.66) | < 0.0001** |
| White            | 79.53          | 74.54               | < 0.0001** | 78.73 | 70.61  | < 0.0001** |
| Black            | 10.62          | 14.79               | < 0.0001** | 12.13 | 20.69  | < 0.0001** |
| Race other       | 9.85           | 10.68               | < 0.0001** | 9.14 | 8.7    | < 0.0001** |
| GERD             | 34.28          | 39.37               | < 0.0001** | 26.07 | 28.66  | < 0.0001** |
| Limited ambulation | 2.3          | 1.81                | < 0.0001** | 1.87 | 1.45   | < 0.0001** |
| Cardiac history (MI or intervention) | 8.17 | 2.49 | < 0.0001** | 6.77 | 2.05 | < 0.0001** |
| HTN              | 68.53          | 49.16               | < 0.0001** | 61.17 | 43.04  | < 0.0001** |
| Hyperlipidemia   | 43.25          | 25.55               | < 0.0001** | 33.77 | 19.12  | < 0.0001** |
| History DVT      | 2.41           | 1.7                 | < 0.0001** | 2    | 1.33   | < 0.0001** |
| Venous stasis    | 2.27           | 0.92                | < 0.0001** | 1.81 | 0.72   | < 0.0001** |
| Renal insufficiency or dialysis | 1.66 | 0.51 | < 0.0001** | 1.74 | 0.56 | < 0.0001** |
| Therapeutic anticoagulation | 5.34 | 2.06 | < 0.0001** | 5.02 | 1.84 | < 0.0001** |
| Previous foregut surgery | 1.4 | 1.8 | < 0.0001** | 1.38 | 1.6 | < 0.0001** |
| Diabetes insulin | 22.21          | 11.93               | < 0.0001** | 10.59 | 5.56   | < 0.0001** |
| Smoker           | 7.54           | 8.45                | < 0.0001** | 9.06 | 8.63   | 0.0005* |
| Total dependence | 0.32           | 0.31                | 0.0227* | 0.49 | 0.42   | < 0.0001** |
| COPD             | 2.44           | 1.86                | < 0.0001** | 2.18 | 1.48   | < 0.0001** |
| Oxygen dependence | 1.12          | 0.84                | < 0.0001** | 0.95 | 0.57   | < 0.0001** |
| History of PE    | 1.42           | 1.21                | 0.0093* | 1.34 | 1.04   | < 0.0001** |
| Sleep apnea      | 64.73          | 38.3                | < 0.0001** | 56.97 | 30.55  | < 0.0001** |
| Chronic steroids | 1.32           | 1.57                | 0.006* | 1.54 | 1.83   | < 0.0001** |

*Significant (p value < 0.05)
**Highly significant (p value < 0.0001)
Table 2  Univariate outcomes

|                      | Male              | Female            | p value  | Male              | Female            | p value  | Male              | Female            | p value  |
|----------------------|-------------------|-------------------|----------|-------------------|-------------------|----------|-------------------|-------------------|----------|
| **OR time**          | 124.53 (57.20)    | 118.64 (53.56)    | < 0.0001** | 77.80 (38.70)    | < 0.0001**       | 90.14 (48.89)    | < 0.0001**       | 84.71 (46.65)     | < 0.0001** |
|                      | ± SD              | ± SD              |          | ± SD              | ± SD              |          | ± SD              | ± SD              |          |
| **Approach converted** | 0.36              | 0.27              | 0.0323*  | 0.11              | 0.1              | 0.3031   | 0.18              | 0.14              | 0.0371*  |
| **Major complication** | 2.62              | 1.61              | < 0.0001** | 1.4               | 0.83             | < 0.0001** | 1.72              | 1.05              | < 0.0001** |
| **Minor complication** | 1.49              | 1.9               | < 0.0001** | 0.54              | 0.72             | < 0.0001** | 0.79              | 1.04              | < 0.0001** |
| **Acute renal failure** | 0.24              | 0.09              | < 0.0001** | 0.11              | 0.04             | < 0.0001** | 0.14              | 0.05              | < 0.0001** |
| **Cardiac arrest req CPR** | 0.15              | 0.04              | < 0.0001** | 0.06              | 0.02             | < 0.0001** | 0.08              | 0.03              | < 0.0001** |
| **Deep incisional SSI** | 0.09              | 0.15              | 0.028*   | 0.03              | 0.02             | 0.3732   | 0.05              | 0.06              | 0.1446   |
| **Myocardial infarction** | 0.11              | 0.03              | < 0.0001** | 0.05              | 0.02             | 0.0003*  | 0.06              | 0.02              | < 0.0001** |
| **Organ space SSI**   | 0.4               | 0.34              | 0.1822   | 0.16              | 0.14             | 0.3826   | 0.22              | 0.2               | 0.163    |
| **Progressive renal failure** | 0.24              | 0.08              | < 0.0001** | 0.12              | 0.03             | < 0.0001** | 0.15              | 0.04              | < 0.0001** |
| **Pneumonia**        | 0.37              | 0.38              | 0.7097   | 0.12              | 0.13             | 0.5681   | 0.19              | 0.2               | 0.3999   |
| **PE**               | 0.2               | 0.15              | 0.1035   | 0.09              | 0.08             | 0.8349   | 0.12              | 0.1               | 0.2619   |
| **Septic shock**     | 0.19              | 0.18              | 0.6894   | 0.08              | 0.07             | 0.4611   | 0.11              | 0.1               | 0.4895   |
| **Superficial SSI**  | 0.77              | 0.92              | 0.0336*  | 0.22              | 0.24             | 0.4198   | 0.37              | 0.43              | 0.0144*  |
| **Discharge other than home** | 0.87              | 0.52              | < 0.0001** | 0.51              | 0.4              | < 0.0001** | 0.6               | 0.43              | < 0.0001** |
| **Unplanned intubation** | 0.41              | 0.2               | < 0.0001** | 0.18              | 0.09             | < 0.0001** | 0.24              | 0.12              | < 0.0001** |
| **UTI**              | 0.27              | 0.57              | < 0.0001** | 0.16              | 0.32             | < 0.0001** | 0.19              | 0.39              | < 0.0001** |
| **VTE**              | 0.22              | 0.16              | 0.0434*  | 0.22              | 0.16             | 0.0023*  | 0.22              | 0.16              | 0.0003*  |
| **Unplanned ICU admission** | 1.76              | 0.96              | < 0.0001** | 0.8               | 0.43             | < 0.0001** | 1.06              | 0.58              | < 0.0001** |
| **30 day mortality** | 0.3               | 0.11              | < 0.0001** | 0.14              | 0.05             | < 0.0001** | 0.18              | 0.07              | < 0.0001** |
| **Percent of deaths related to surgery** | 56.52             | 52.83             | < 0.0001** | 49.45             | 50.42            | < 0.0001** | 52.5              | 51.56             | < 0.0001** |
| **Reoperation 30 days** | 2.25              | 2.2               | 0.6828   | 0.98              | 0.79             | < 0.0001** | 1.32              | 1.18              | 0.0011*  |
| **Readmission 30 days** | 5.3               | 6                 | < 0.0001** | 2.86              | 3.07             | < 0.0001** | 3.5               | 3.88              | < 0.0001** |
| **Intervention 30 days** | 2.14              | 2.48              | 0.0025*  | 0.84              | 0.91             | 0.0772   | 1.18              | 1.34              | 0.0002*  |
| **Dehydration**      | 0.19              | 0.5               | < 0.0001** | 0.08              | 0.23             | < 0.0001** | 0.11              | 0.3               | < 0.0001** |
| **VTE**              | 0.02              | 0.01              | 0.1368   | 0.02              | 0.02             | 0.1549   | 0.02              | 0.01              | 0.0512   |
| **Bleeding**         | 0.37              | 0.22              | < 0.0001** | 0.07              | 0.03             | 0.0002*  | 0.15              | 0.08              | < 0.0001** |
| **Leak**             | 0.12              | 0.09              | 0.247    | 0.14              | 0.12             | 0.1131   | 0.14              | 0.12              | < 0.0490*  |

*Significant (p value < 0.05)

**Highly significant (p value < 0.0001)
To our knowledge there is not a study specifically assessing the validity of preoperative cardiac workups before bariatric surgery. This would make for an interesting and important future study to conduct.

The reasons behind gender disparity in bariatric surgery have been previously investigated and consistently report less males undergo bariatric surgery than females, despite having equal or better results. Several studies have focused on gender differences in weight loss following bariatric surgery with findings suggesting higher, equal, or less weight loss in males [10–12]. However, it should be noted that the difference in excess weight loss between males and females averaged only 5% in either direction in these reports, suggesting the clinical and overall health impact of such differences are likely to be small. Despite these similarities in weight loss between sexes, males are reported to have improved psychological benefits after bariatric surgery compared to females. For example, Kochkodan et al. evaluated surveys from more than 61,000 patients from the Michigan Bariatric Surgery Collaborative in 2018, and report males were found to have higher post-operative satisfaction, body image, and psychological wellbeing scores compared to females who underwent the same procedure concomitant with lower post-operative depression scores in males [13].

These findings pose several important clinical questions; if males and females have similar obesity rates and similar weight loss results after bariatric surgery, why does such a large gender gap remain between sexes for those undergoing bariatric surgery? From a broader perspective, the World Health Organization has investigated gender disparities in health care and report that (overall) men use health services less often than females, and are less likely to report symptoms when they do present to a health care provider. These findings correlate with the continued trend of male life expectancy growing at a slower rate than females, despite similar advances in healthcare [14]. This broad gender gap in healthcare also applies when considering obesity. Surveys report males to have lower body dissatisfaction scores, and to be more satisfied with their health and fitness overall, compared to females with similar BMIs [15] suggesting males may be less likely to seek medical treatment of their obesity because of their perceived “relative health”.

### Table 3 Propensity score matched patient characteristics

|                      | Gastric bypass |                      | Sleeve gastrectomy |                      |
|----------------------|----------------|----------------------|--------------------|----------------------|
|                      | Male           | Female               | \( p \) value      | Male                | Female              | \( p \) value      |
| Mean age ± SD        | 45.08 (11.88)  | 44.98 (11.86)        | 0.8123             | 43.94 (12.09)       | 44.02 (11.96)       | 0.9117             |
| Mean BMI at surgery ± SD | 46.26 (8.04)  | 46.10 (8.02)         | 0.9654             | 45.25 (7.83)        | 45.05 (7.87)        | 0.9983             |
| White                | 75.87          | 75.56                | 0.6246             | 72.33               | 72.32               | 0.9995             |
| Black                | 13.79          | 13.96                | 0.6246             | 18.88               | 18.9                | 0.9995             |
| Race other           | 10.34          | 10.48                | 0.6246             | 8.79                | 8.9                 | 0.9995             |
| GERD                 | 38.16          | 38.36                | 0.4727             | 28.08               | 28.11               | 0.8325             |
| Limited ambulation   | 1.89           | 1.9                  | 0.8504             | 1.52                | 1.53                | 0.7577             |
| Cardiac history (MI or intervention) | 3.58   | 3.6                  | 0.8617             | 3.02                | 3.02                | 0.9934             |
| HTN                  | 53.23          | 52.99                | 0.8123             | 46.86               | 46.81               | 0.9117             |
| Hyperlipidemia       | 29.08          | 29.02                | 0.8466             | 22.19               | 22.15               | 0.8006             |
| History DVT          | 1.80           | 1.84                 | 0.6319             | 1.44                | 1.47                | 0.5072             |
| Venous stasis        | 1.13           | 1.15                 | 0.6935             | 0.92                | 0.94                | 0.6093             |
| Renal insufficiency and dialysis | 0.71 | 0.72                  | 0.8666             | 0.79                | 0.80                | 0.9405             |
| therapeuic anticoagulation | 2.64   | 2.69                 | 0.5923             | 2.48                | 2.49                | 0.8657             |
| Previous foregut surgery | 1.65  | 1.72                 | 0.3669             | 1.55                | 1.54                | 0.8339             |
| Diabetes insulin     | 14.01          | 13.97                | 0.9763             | 6.63                | 6.60                | 0.8188             |
| Smoker               | 8.14           | 8.28                 | 0.389              | 8.76                | 8.71                | 0.6715             |
| Dependency           | 0.29           | 0.31                 | 0.5291             | 0.42                | 0.43                | 0.7931             |
| COPD                 | 1.74           | 2.03                 | 0.0003*            | 1.57                | 1.65                | 0.0636             |
| Oxygen dependence    | 0.83           | 0.89                 | 0.3311             | 0.62                | 0.64                | 0.4063             |
| History of PE        | 1.31           | 1.24                 | 0.0704             | 1.05                | 1.10                | 0.222              |
| Sleep apnea          | 43.83          | 43.52                | 0.286              | 36.18               | 36.04               | 0.4383             |
| Chronic steroids     | 1.44           | 1.52                 | 0.239              | 1.76                | 1.77                | 0.8191             |

*Significant \((p \text{ value} < 0.05)\)

**Highly significant \((p \text{ value} < 0.0001)\)
Similarly since more women are likely to seek treatment for their obesity, when males do utilize health services, is there equivalence in efforts made by health care providers to counsel males on obesity and weight loss surgery? Chang and colleagues addressed this issue in 2017 by reviewing data from 66,263 clinic visits of patients with BMIs > 35 over a 15 year period (2000–2015) [16]. Data from this study report that despite males being counseled more frequently on bariatric surgery for weight loss (2.9% of males with BMI 42–45 kg/m² vs. 2.0% of females; 6.2% of males with BMI > 45 kg/m² vs. 3.7% of females) male patients were less likely to consider bariatric surgery than females of similar BMIs [16]. One potential explanation of these findings may be that males have higher obesity related quality of life scores and are more likely to think of bariatric surgery as being too risky [17]. These data suggest a more significant component of the bariatric surgery gender gap lies with disparities in perception males have for the impact of weight/weight loss on quality of life, as opposed to availability of counseling for weight loss surgery.

Previous studies investigating gender disparities and outcomes in patients undergoing bariatric surgery report males present to surgery with more comorbidities and with higher rates of morbidity and mortality following surgery [5, 6, 18, 19]. Similarly, our analysis identified males presented on average 3 years older and 1.55 BMI points heavier than females. In addition, males had significantly higher prevalence of comorbidities (including hypertension, MI or history of cardiac procedure, diabetes, COPD, OSA, and hyperlipidemia) indicating males were higher risk patients for bariatric surgery. Given the differences in preoperative health, it was of little surprise that males had higher

| Table 4 | Propensity score matched outcomes |
|---------|----------------------------------|
|         | Gastric bypass | Sleeve gastrectomy |
|         | Male | Female | p value | Male | Female | p value |
| OR time (min) ± SD | 122.48 (57.08) | 119.07 (53.73) | < 0.0001** | 76.42 (37.79) | 72.04 (36.27) | < 0.0001** |
| Approach converted | 0.27 | 0.28 | 0.7477 | 0.1 | 0.1 | 0.6644 |
| Major complication | 2.21 | 1.7 | < 0.0001** | 1.12 | 0.89 | < 0.0001** |
| Minor complication | 1.33 | 1.97 | < 0.0001** | 0.43 | 0.75 | < 0.0001** |
| Acute renal failure | 0.17 | 0.1 | 0.0019* | 0.08 | 0.04 | < 0.0001** |
| Cardiac arrest req CPR | 0.1 | 0.04 | < 0.0001** | 0.04 | 0.03 | 0.0496* |
| Deep incisional SSI | 0.08 | 0.16 | 0.0004* | 0.03 | 0.02 | 0.723 |
| Myocardial infarction | 0.08 | 0.04 | 0.0023* | 0.03 | 0.03 | 0.918 |
| Organ space SSI | 0.37 | 0.35 | 0.0423* | 0.15 | 0.15 | 0.9593 |
| Progressive renal failure | 0.17 | 0.08 | < 0.0001** | 0.08 | 0.04 | < 0.0001** |
| Pneumonia | 0.31 | 0.4 | 0.0068* | 0.1 | 0.14 | 0.0002* |
| PE | 0.18 | 0.15 | 0.242 | 0.09 | 0.08 | < 0.0001** |
| Sepsis | 0.17 | 0.18 | 0.6968 | 0.06 | 0.07 | 0.7341 |
| Septic shock | 0.14 | 0.1 | 0.052 | 0.04 | 0.03 | 0.6903 |
| Superficial SSI | 0.71 | 0.95 | < 0.0001** | 0.19 | 0.25 | 0.4944 |
| Discharge other than home | 0.72 | 0.54 | < 0.0001** | 0.43 | 0.41 | 0.0037* |
| Unplanned intubation | 0.33 | 0.21 | < 0.0001** | 0.12 | 0.1 | 0.025* |
| UTI | 0.21 | 0.59 | < 0.0001** | 0.12 | 0.34 | < 0.0001** |
| VTE | 0.2 | 0.16 | 0.1415 | 0.21 | 0.16 | 0.002* |
| Unplanned ICU admission | 1.46 | 1.02 | < 0.0001** | 0.61 | 0.48 | < 0.0001** |
| 30 day mortality | 0.23 | 0.12 | < 0.0001** | 0.1 | 0.05 | < 0.0001** |
| Percent of deaths related to surgery | 57.79 | 51.75 | < 0.0001** | 54.55 | 49.7 | < 0.0001** |
| Reoperation 30 days | 2.19 | 2.2 | 0.9436 | 0.91 | 0.81 | 0.001* |
| Readmission 30 days | 4.97 | 6.03 | < 0.0001** | 2.6 | 3.11 | < 0.0001** |
| Intervention 30 days | 2.14 | 2.48 | < 0.0001** | 0.84 | 0.91 | 0.0002* |
| Dehydration | 0.2 | 0.49 | < 0.0001** | 0.09 | 0.22 | < 0.0001** |
| VTE | 0.02 | 0.01 | 0.5307 | 0.02 | 0.02 | 0.1222 |
| Bleeding | 0.32 | 0.23 | 0.0024* | 0.06 | 0.03 | 0.0005* |
| Leak | 0.13 | 0.09 | 0.0663 | 0.13 | 0.12 | 0.3657 |

*Significant (p value < 0.05)
**Highly significant (p value < 0.0001)
post-operative 30-day major complications and mortality rates compared to females, even when sub-dividing patients into RYGB and SG procedures. Indeed, our findings were similar to previously published studies analyzing data from 2005 to 2011 in which males were reported as having higher morbidity and mortality rates compared to females after bariatric surgery [5, 6]. However, it should be noted the morbidity and mortality rates in our study were significantly lower for both genders than reported in these studies in line with the improved safety profile of bariatric surgery over the past decade. Our analysis did demonstrate a significant difference in leak rates between males and females. However, the difference was only 0.02% and we did not consider this to be clinically relevant.

In order to assess male gender as an independent risk factor, propensity matching was performed. After matching, the pre-operative demographics and comorbidity profiles were no longer different between males and females. However, 30-day major complications and mortality rates remained significantly higher in males than females (after both RYGB or SG), establishing male gender as an independent risk factor for patients undergoing primary RYGB or SG. These data reflect similar conclusions drawn from previous studies (albeit these studies having smaller patient cohorts than our analysis). For example, Carbon et al. used a multiple logistic regression approach to determine female gender to be protective against morbidity and mortality in patients undergoing gastric bypass (odds ratio of 0.65 and 0.34 respectively) [6]. while Lazzati et al. established male gender to be an independent risk factor in patients undergoing either, laparoscopic adjustable gastric band (LAGB), SG, or RYGB (male post-operative mortality odds ratio of 1.94) [18].

After accounting for differences in preoperative comorbidities, many of the post-operative complications that could be attributed to higher mortality rates in males lose significance, or are no longer highly significant (p < 0.0001) (e.g. post-operative MI and septic shock). However, complications which remained highly significant after accounting for differences in preoperative comorbidities included death related to surgery and operative time. Therefore, one possible reason males continue to have higher mortality, despite controlling for comorbidities, is the increased difficulty of the operation due to male gender. This operative difficulty could be because males tend to have more central obesity (and therefore thicker abdominal walls) and more intraabdominal adipose tissue compared to females. An exception to these findings was that females had higher 30-day readmission rates for both RYGB and SG procedures due to higher rates of post-operative dehydration that required re-admission. However, this difference may not be due to female gender being a risk factor for dehydration/re-admission per se, but because males are less likely (overall) to seek medical attention.

Limitations of this study include the observational nature of large registry database studies. Although the MBSSAQIP® is collected in a prospective manner, there is still significant selection bias (as with any observational study). For instance, males tend to not present for bariatric surgery until they have significant comorbidities while females tend to have surgery before their health deteriorates. Additionally, propensity matching was difficult due to the number of unhealthy males and lack of sufficient unhealthy females to match with. Overall, these limitations should be balanced against strength of the study provided by the large sample size contained within the MBSSAQIP® database that allows for detailed analysis of rare events (such as mortality) to be performed with sufficient statistical power.

Conclusions

Despite the similar prevalence of obesity in males and females the gender disparity among patients having bariatric surgery remains, with males representing only 20% of all bariatric surgery patients. While males do present to surgery with significantly more comorbidities than females, male gender remains as an independent risk factor for major post-operative complications and 30-day mortality, even when comorbidities are controlled for. Therefore, a more rigorous preoperative work up, including cardiac evaluation, should be considered in male patients prior to bariatric surgery.

Compliance with ethical standards

Disclosures Keith S. Gersin, Timothy S. Kuwada are speakers for WL Gore and Abdelrahman Nimeri speaker for Medtronic. Nicholas Dugan, Selwan Barbat, Tanushree Prasad, Kyle J. Thompson, Iain H. McKillop, Sean R. Maloney, Amanda Roberts have no conflicts of interest or financial ties to disclose.

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