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The goal of this article is to review the status of the emerging field of laparoscopic bariatric surgery, to discuss developmental issues regarding technique and training, and finally, to summarize the present and future roles of laparoscopic bariatric surgery. We reviewed all published literature from 1992 to the present on MEDLINE. Articles were excluded for analyses that were case reports or articles on technical aspects of given procedures. Laparoscopic vertical banded gastroplasty (LVBG) has reduced perioperative morbidity compared with the open approach but seems to have a low overall adoption rate, at least, in the United States. Laparoscopic adjustable silicone gastric banding (LASGB) has become firmly established in Europe and Australia. It has only recently been introduced in the United States. Laparoscopic adjustable silicone gastric banding has been proven to be an effective weight loss procedure in Europeans with morbid obesity. Laparoscopic Roux-en-Y gastric bypasses (LRYGBPs) can also be safely performed laparoscopically with weight loss similar to open Roux-en-Y gastric bypass surgery. Laparoscopic biliopancreatic diversion procedures (LBPDs) have been performed safely in a few small series, but overall, experience is insufficient to draw strong conclusions. All laparoscopic bariatric procedures have significant learning curves. Laparoscopic bariatric surgery can be safely performed for all types of bariatric operations. The laparoscopic approaches to bariatric surgery significantly reduce perioperative morbidity justifying the acquisition of skills needed to perform these procedures.

Two major events characterize the current era of bariatric surgery. The first event is the accumulation of numerous outcome-based studies that provide reliable information on both short-term and long-term results of bariatric operations that have been proven to be relatively safe and effective. The second event is the development, maturation, and application of laparoscopic techniques to the field of bariatric surgery. Laparoscopy in bariatric surgery is a major advance because it reduces perioperative morbidity and speeds recovery.

Current laparoscopic approaches to bariatric operations include LVBG, LASGB, LRYGBP, and LBPDs. The transition from second-generation procedures, such as laparoscopic Nissen fundoplication, to laparoscopic bariatric operations has been arduous because of the technical complexity of the procedures. Sufficient experience is available to review the outcomes of the following 4 bariatric procedures: LVBG, LASGB, LRYGBP, and LBPD. The goal of this article is to review the status of the emerging field of laparoscopic bariatric surgery, to discuss developmental issues regarding training, and finally, to summarize the present and future roles of laparoscopic bariatric operations.
### Table 1. Outcomes for Open Gastric Bypass Surgery: Selected Series

<table>
<thead>
<tr>
<th>Source</th>
<th>Total No. of Patients</th>
<th>Size of Patient, BMI or IBW*</th>
<th>Length of OR Time, min</th>
<th>Length of Hospital Stay, d</th>
<th>Early Complication Rate, %</th>
<th>Mortality, %</th>
<th>Pulmonary Embolism Rate, %</th>
<th>Leakage Rate, %</th>
<th>Hernia Rate, %</th>
<th>Duration of Follow-up, mo</th>
<th>Weight Loss, kg</th>
<th>EWL, %</th>
</tr>
</thead>
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<tr>
<td>Mason and Litovitz, 1983</td>
<td>26</td>
<td>BMI 42</td>
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<tr>
<td>Griffen et al., 1981</td>
<td>402</td>
<td>BMI 134</td>
<td>NI</td>
<td>NI</td>
<td>4.2</td>
<td>0.7</td>
<td>0.2</td>
<td>5.5</td>
<td>3.5</td>
<td>6</td>
<td>35</td>
<td>NA</td>
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<tr>
<td>Linner, 1982</td>
<td>174</td>
<td>BMI 126</td>
<td>NI</td>
<td>NI</td>
<td>10.4 (all)</td>
<td>0.6</td>
<td>0</td>
<td>0.6</td>
<td>0</td>
<td>24</td>
<td>NA</td>
<td>64</td>
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<td>Superman et al., 1989 Hall et al.</td>
<td>182</td>
<td>IBW 213</td>
<td>6-7</td>
<td>NI</td>
<td>1.0</td>
<td>0.0</td>
<td>1.6</td>
<td>18</td>
<td>12</td>
<td>12</td>
<td>NA</td>
<td>67</td>
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<tr>
<td>1990</td>
<td>99</td>
<td>IBW 198</td>
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<td>8</td>
<td>20.0</td>
<td>3.0</td>
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<td>36</td>
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<td>67</td>
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<td>Brolin et al., 1992</td>
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<td>BMI 62</td>
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<td>1.1</td>
<td>0</td>
<td>6.6</td>
<td>43</td>
<td>43</td>
<td>NA</td>
<td>64</td>
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<tr>
<td>Maclean et al., 1993</td>
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<td>BMI 50</td>
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<td>NI</td>
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<td>0</td>
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<td>6.6</td>
<td>33</td>
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<td>64</td>
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<tr>
<td>Pories et al., 1995</td>
<td>608</td>
<td>BMI 50</td>
<td>5-6</td>
<td>NI</td>
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<td>0</td>
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<td>168</td>
<td>168</td>
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<td>49</td>
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<td>Capella and Capella, 1996</td>
<td>560</td>
<td>BMI 52</td>
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<td>NI</td>
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<td>0</td>
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<td>BMI 46</td>
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<td>0.6</td>
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<td>BMI 49</td>
<td>NI</td>
<td>NI</td>
<td>0.4</td>
<td>0.0</td>
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<td>0</td>
<td>Nil</td>
<td>66</td>
<td>NA</td>
<td>44/29†</td>
</tr>
<tr>
<td>2002</td>
<td>652</td>
<td>BMI 50</td>
<td>NI</td>
<td>NI</td>
<td>3.0</td>
<td>0.3</td>
<td>0.3</td>
<td>28.0</td>
<td>60</td>
<td>60</td>
<td>NA</td>
<td>77</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; EBL, excess body weight; EWL, excess weight loss; IBW, ideal body weight; NA, not applicable; NI, not indicated; OR, operating room.

*The BMI is calculated as the weight in kilograms divided by the height in meters squared; IBW is given as a percentage.

†Value given as preoperative BMI/postoperative BMI.

### CURRENT BENCHMARK FOR BARIATRIC SURGERY

The RYGBP is the most commonly performed bariatric procedure in the United States. Furthermore, there are numerous studies documenting both short-term and long-term outcomes. These studies, listed in Table 1, collectively suggest that open RYGBP results in a hospital stay ranging from 4 to 8 days, a perioperative complication rate of 3% to 20%, a mortality rate of 0% to 1%, a pulmonary embolism rate of 0% to 3%, a leakage rate of 0% to 5%, and a hernia rate of 5% to 28%. Operative time and hospital stay were not reliably reported in most studies. Long-term weight loss at 5 to 15 years seems to be 49% to 77% of excess body weight. Most morbidities including hypertension, sleep apnea, osteoarthritis, type 2 diabetes mellitus, and gastroesophageal reflux are improved or resolved and the quality of life is significantly improved. Late complications may include marginal ulcer, bowel obstruction, and anastomotic stricture. Late nutritional deficiencies are a consequence of the foregut bypass and include iron deficiency anemia (up to 47%), vitamin B deficiency (up to 40%), folate deficiency (up to 18%), and other micronutrient deficiencies. Most of these nutrient deficiencies can be circumvented by adequate dietary supplementation. Protein malnutrition, however, is not a recognized complication of RYGBP. It is against these benchmarks that all bariatric operations, laparoscopic or open, should be judged.

### RATIONALE FOR A LESS INVASIVE APPROACH TO BARIATRIC SURGERY

As experience with open bariatric procedures has progressed, complication rates have steadily decreased. However, cardiopulmonary and wound complications still remain a major problem. By minimizing the access incision, the surgeon using a laparoscopic procedure has a strong potential to significantly reduce recovery time and morbidity associated with laparotomy. Evidence favoring the laparoscopic approach for major abdominal operations is the reduction of the stress response to surgery. Studies have shown that laparoscopic surgery offers better preserved cell-mediated immunity and decreased levels of catecholamines, cortisol, glucose, cytokines, and other acute-phase reactants compared with laparotomy. Although not definitively proven, the reduced stress response may translate to a reduction in incidence and severity of related complications. Cardiopulmonary complications have been shown to occur less commonly after laparoscopic procedures compared with laparotomy. Preserved pulmonary function is the most well-documented benefit of laparoscopic surgery, with comparatively less impairment in post-
operative ventilation, total lung capacity, and oxygen saturation. Reduced postoperative pulmonary compromise attributed to laparoscopy directly results in fewer pulmonary complications. The gastrointestinal system also benefits from laparoscopy. Postoperative ileus is less common and of shorter duration following laparoscopic procedures. Adhesion-related morbidity such as infertility, bowel obstruction, and chronic abdominal pain are reduced following laparoscopic surgery. Additionally, laparoscopic access has dramatically reduced the incidence and magnitude of wound-related complications including hernias, seromas, infections, hematomas, and dehiscences.

Overall operative morbidity and mortality, particularly in high-risk patients, may be reduced by the laparoscopic approach as demonstrated in comparative studies of laparoscopic vs open cholecystectomy. Obese patients are generally at higher risk than nonobese patients for cardiovascular and pulmonary risks, along with higher rates of thromboembolic events, postoperative infections, and wound complications. Thus, despite good or acceptable outcomes for open bariatric operations, the well-documented benefits of laparoscopic surgery in nonobese patients may be even more profound in obese patients. Supportive evidence comes from one retrospective study comparing laparoscopic cholecystectomy with open cholecys-

tectomy in patients with morbid obesity that demonstrated that the laparoscopic approach was associated with a significant reduction in morbidity and mortality in high-risk patients who have diabetes mellitus. Finally, Nguyen et al. in an elegant series of prospective randomized studies showed that laparoscopic compared with open gastric bypass surgery resulted in less blood loss, reduced pulmonary complications, shorter hospital stay, faster recovery, and reduced need for intensive care. In summary, strong evidence suggests that the benefits for the laparoscopic approach to bariatric operations more than justify the effort to develop and to perfect these techniques.

LAPAROSCOPIC VERTICAL BANDED GASTROPLASTY

All variations of LBGs (Figure 1) are derived from the Mason gastroplasty. The experience with LBG comes predominantly from Europe. Surgeons in the United States seem reluctant to consider LBG because long-term weight loss after open VBG seems less favorable than that of RYGB. Furthermore, complications such as gastroesophageal reflux disease (16%) and frequent vomiting (21%) are common.

To date there are several studies of LBG with short follow-up periods that have been published, mostly by European surgeons (Table 2). These studies should be interpreted considering that most of the patients are European and have low body mass indexes (BMIs) in the 40s, who, for unclear reasons, respond better to gastric restrictive procedures than do patients in the United States. Mean operative time ranges from 60 to 120 minutes with hospital stays of 1 to 4 days. Conversion rates range from 1% to 12%. The most common complications include bleeding (0%-2%), fistula (0%-1.5%), subphrenic abscess (0%-2%), gastric perforation (0%-2%), outlet stenosis (0%-6%), deep vein thrombosis—pulmonary embolism (0%-2%), and pulmonary complications (0%-3%). Wound infections were uncommon. Late complications after LBG that may require reoperation include new onset gastroesophageal reflux (0.5%-12%), staple-line fistula (0%-3%), food intolerance (0%-2%), outlet stenosis (0%-2%), pouch enlargement (0%-2%), and port-site incisional hernia (0%-0.5%). Mortality varied from 0% to 1.7%, with pulmonary embolus being the most common.

Figure 1. View of completed vertical banded gastroplasty (Reprinted from Schauer P, Hamad G, Ibrahimdin S. Surgical management of gastroesophageal reflux disease in obese patients. Semin Laparosc Surg. 2001;8:256-264, with permission from Elsevier.)

<table>
<thead>
<tr>
<th>Source</th>
<th>Total No. of Patients</th>
<th>Conversion Rate, %</th>
<th>Complication Rate, %</th>
<th>Length of OR Time, min</th>
<th>Length of Hospital Stay, d</th>
<th>Duration of Follow-up, mo</th>
<th>Type of Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alle et al., 1998</td>
<td>261</td>
<td>85.4</td>
<td>43.3</td>
<td>102</td>
<td>1.1</td>
<td>1.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Goergen et al., 1999</td>
<td>203</td>
<td>79.8</td>
<td>43.0</td>
<td>120</td>
<td>2.8</td>
<td>2.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Lonrot and Dalenback, 1998</td>
<td>105</td>
<td>75.2</td>
<td>41.0</td>
<td>NI</td>
<td>5.7</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Naslund et al., 1999</td>
<td>60</td>
<td>83.0</td>
<td>44.4</td>
<td>115</td>
<td>25.0</td>
<td>6.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Salva et al., 1999</td>
<td>87</td>
<td>86.0</td>
<td>43.4</td>
<td>NI</td>
<td>0</td>
<td>12.6</td>
<td>7.4</td>
</tr>
<tr>
<td>Toppino et al., 1999</td>
<td>170</td>
<td>NI</td>
<td>45.9</td>
<td>95</td>
<td>0.6</td>
<td>4.7</td>
<td>4.0</td>
</tr>
<tr>
<td>Morino et al., 2002</td>
<td>250</td>
<td>87.0</td>
<td>46.0</td>
<td>95</td>
<td>0.8</td>
<td>4.4</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; EWL, excessive weight loss; NI, not indicated; OR, operating room; ↓, decrease.
*The BMI is calculated as the weight in kilograms divided by the height in meters squared.
cause of death. Weight loss, with follow-up of less than 3 years in most series, seems to be slightly higher than reported for open VBG (ie, 40%-50% excess weight loss) for unexplainable reasons.

**LAPAROSCOPIC ADJUSTABLE SILICONE GASTRIC BANDING**

Laparoscopic adjustable silicone gastric banding (Figure 2) was first introduced by Belachew et al in 1993. It is a purely gastric restrictive procedure that involves the use of an adjustable silicone band placed around the gastric cardia to create a small (15-ml) gastric pouch with a narrow outlet similar to that of the VBG. Presently, in the United States only the BioEnterics Lap-Band System (Inamed Health, Santa Barbara, Calif) has been approved for use by the Food and Drug Administration. Among other adjustable gastric banding systems, the Swedish Adjustable Gastric Band (Obtech Medical, Baar, Switzerland), the Midband (Medical Innovation Development, Villuberne, France), and the Heligast Band (Helioscopic, Vienne, France) are included. These banding systems have an inflatable saline reservoir that can adjust the luminal diameter postoperatively by percutaneous access of a subcutaneous port placed in the abdominal wall. Laparoscopic adjustable silicone gastric banding differs from VBG in that the band diameter may be decreased to minimize adverse effects such as vomiting or may be increased to enhance weight loss.

Nearly a decade of experience with LASGB has been accumulated outside of North America, with an estimated patient experience of more than 100,000. Findings from several large series (>200 patients) with intermediate follow-up (up to 6 years) have been published mostly by surgeons from Europe and Australia (Table 3). Operative times ranging from 35 to 90 minutes seem shorter than those of LVBG, and conversion rates are generally less than 3%. The most common operative complications include bleeding (0%-1%) and gastric perforation (0%-1%). The most common early complications (<30 days) include food intolerance (0%-11%), wound infections (0%-1%), pneumonia (0.8%), deep vein thrombosis—pulmonary embolism (0.8%), and bleeding (0.5%). Late complications of the band that frequently require reoperation are relatively common and include food intolerance (13%), band slippage (2.2%-8%), pouch dilatation (3%), and band erosion (1%). Improved fixation techniques seem to lessen band slippage. Port-specific complications include infection (1%-2%), kinking (0.5%), and tube defects (0.5%), all of which may require replacement. Reoperation is variable (2%-41%), with band slippage being the most common cause. Reoperation for failure of adequate weight loss was not reported by most authors but may add to the reoperation rate over time. Technical complications of LASGB seem to decrease significantly with surgeon experience. Mortality for laparoscopic banding seems consistently low (0%-0.5%).

Some surgeons have noted the occurrence of significant esophageal dilatation after band tightening. This condition seems to be either rare or underreported since most LASGB series report no occurrence of esophageal dysfunction. This pseudoachalasialike condition has potentially harmful long-term implications for esophageal motility. Weiss et al showed that in 28% of patients, an LASGB resulted in a 2-fold increase in impaired esophageal motility, a 2-fold decrease in lower esophageal sphincter relaxation, and a marked increase in esophageal diameter (28% of patients), even though patients denied dysphagia. Weiss et al did not address whether these changes were reversible after band loosening. Lovino et al, however, found no significant changes in esophageal motility 18 months after band placement. The significance of these findings remains unclear and controversial, but these findings suggest that long-term surveillance of esophageal motility with motility studies and barium swallow tests may be indicated until the issue is resolved.

Only Favretti et al and O'Brien et al (Table 3) have published large laparoscopic band series with longer than 5-year results. They showed that the mean BMI changed from 42.7 and 45.0, respectively, to 29.7 and 31.0. O'Brien et al found that at 4 to 6 years after surgery their patients achieved a mean estimated weight loss between 52% and 57% with an overall band removal rate of 11% (most were replaced with new repositioned bands). Favretti et al showed that at 3 years 70% of their patients were able to achieve an estimated weight loss exceeding 30%. In their study, weight loss was best in patients with lower BMIs. The super obese patients (BMI >55) had a mean BMI of 55.7 preoperatively and a BMI of 36.0 at 5 years while those with a mean BMI of 42.7 preoperatively had a BMI of 29.7 at 5 years. Chevallier et al had similar findings to Fourth. Contrary to these findings, Fielding et al showed that super obese patients (mean preoperative BMI of 67) can achieve equally good weight loss with a resultant BMI in the 35 to 36 range.

The findings from these studies suggest that laparoscopic banding techniques are associated with a short hospital stay, rapid recovery, minimal perioperative morbidity and mortality, and good intermediate-term weight loss in a European and Australian population of patients with morbid obesity. Potential advantages include adjustability and complete reversibility on removal of the device, with no stapling or dividing of native tissue required. Disadvantages include the development
### Table 3. Selected Laparoscopic Adjustable Silastic Banding Series

<table>
<thead>
<tr>
<th>Source</th>
<th>Total No. of Patients</th>
<th>Female, %</th>
<th>BMI*</th>
<th>Preoperative Length of OR, min</th>
<th>Conversion Rate, %</th>
<th>Early Complication Rate, %</th>
<th>Length of Hospital Stay, d</th>
<th>Mortality, %</th>
<th>Reoperation Rate, %</th>
<th>Duration of Follow-up, mo</th>
<th>Type of Weight Loss</th>
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<tr>
<td>Feilding et al.11, 1993</td>
<td>335</td>
<td>82</td>
<td>47</td>
<td>71</td>
<td>0.9</td>
<td>2.1</td>
<td>1.4</td>
<td>0</td>
<td>3.5</td>
<td>18</td>
<td>82</td>
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<td>O'Brien et al.10, 1999</td>
<td>277</td>
<td>88</td>
<td>45</td>
<td>57</td>
<td>1.8</td>
<td>4.3</td>
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<td>4.0</td>
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<td>70</td>
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<td>Dargent.14, 1999</td>
<td>500</td>
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<td>NI</td>
<td>NI</td>
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<td>NI</td>
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<td>0</td>
<td>NI</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td>Bianco et al.17, 2001</td>
<td>407</td>
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<td>48</td>
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<td>NI</td>
<td>0</td>
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<td>58 kg loss</td>
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<td>Angrisani.18, 2001†</td>
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<td>41.0†</td>
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<td>38</td>
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<td>47</td>
<td>65</td>
<td>0.3</td>
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<td>0</td>
<td>12.0</td>
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<td>71</td>
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<td>400</td>
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<td>0</td>
<td>27.0</td>
<td>24</td>
<td>47</td>
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<tr>
<td>Pontirolli et al.26</td>
<td>143</td>
<td>81</td>
<td>45</td>
<td>NI</td>
<td>2.8</td>
<td>NI</td>
<td>2.2</td>
<td>0</td>
<td>8.3</td>
<td>36</td>
<td>NA</td>
</tr>
<tr>
<td>Doherty et al.27</td>
<td>22</td>
<td>78</td>
<td>47</td>
<td>NI</td>
<td>32.6</td>
<td>NI</td>
<td>NI</td>
<td>0</td>
<td>40.0</td>
<td>72</td>
<td>15</td>
</tr>
<tr>
<td>Belachew et al.28, 2002</td>
<td>763</td>
<td>78</td>
<td>42</td>
<td>42</td>
<td>1.3</td>
<td>13.9</td>
<td>NI</td>
<td>0.1</td>
<td>11.1</td>
<td>48</td>
<td>NA</td>
</tr>
<tr>
<td>Favretti et al.29</td>
<td>830</td>
<td>78</td>
<td>46.4</td>
<td>NI</td>
<td>2.7</td>
<td>0.2</td>
<td>NI</td>
<td>0</td>
<td>16.8</td>
<td>72</td>
<td>NA</td>
</tr>
<tr>
<td>O'Brien et al.30, 2002</td>
<td>655</td>
<td>86</td>
<td>45</td>
<td>55</td>
<td>1.0</td>
<td>1.2</td>
<td>NI</td>
<td>0</td>
<td>18.9</td>
<td>72</td>
<td>57</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; EWL, excessive weight loss; NA, not applicable; NI, not indicated; OR, operating room.
*The BMI is calculated as the weight in kilograms divided by the height in meters squared.
†This is a multicenter study.
‡This is the percentage of bands that was subsequently removed and does not include the immediate reoperative rate which was unreported.

of device-specific complications such as band migration, band erosion into the gastrointestinal tract, dilation of the esophagus, significant rate of reoperation, long learning curve for the surgeon, frequent adjustments of the band, and its lack of proven efficacy in the super obese patient. Laparoscopic adjustable silicone gastric banding is the dominant operation for severe obesity in Europe and Australia. Its role in the North America remains to be determined.

**LAPAROSCOPIC ROUX-EN-Y GASTRIC BYPASS**

The gastric bypass operation for severe obesity is the most commonly performed bariatric operation in the United States (Figure 3) and has evolved considerably (with many variations) since the loop gastric bypass described by Mason and Ito in 1969. Laparoscopic Roux-en-Y gastric bypass simulates the open procedure and was first described by Wittgrove et al. They have reported their experience with 500 patients and an up to 5-year follow-up. Table 4 summarizes the results of reported series of LRYGBP. Significant variations include variable Roux-limb lengths (75-250 cm), antecolic vs retrocolic Roux limbs, and banded vs nonbanded gastric pouch outlets.

As opposed to the LVBG and the LASGB series, the gastric bypass series have heavier patients with mean BMIs in the high 40s or low 50s. Some series include patients with BMIs exceeding 70. Operating time generally ranges from 2 to 4 hours and seems to lengthen with an increasing BMI but shortens with the surgeon’s experience. Conversion rates are less than 3%. Al-
though there seems to be significant variability in methods for detecting and reporting complications, both early and late complication rates (3.3%-15.0% and 2.2%-27.0%, respectively) are reasonably low. The mean hospital stay (including complications) is typically 2 to 3 days. Most series have a mean follow-up of less than 2 years but consistently demonstrate a favorable estimated weight loss of 62% to 77%.

Noteworthy specific complications after LRYGBP include leaks (1%-3%) and bowel obstructions (1%-3%). The larger series report a slightly higher leakage rate, particularly at the gastrojejunal anastomosis, in their early experience that seems to decrease with additional experience. Leaks, however, did not appear to contribute directly to mortality in these series. Most groups reported bowel obstructions related to internal hernias resulting from unclosed mesenteric defects. We advocate, as do others, closure of all potential mesenteric defects at the enterenterostomy window through the transverse mesocolon, and between transverse mesocolon and Roux-limb mesentry (Petersen defect). An antecolic Roux-limb may reduce the risk of herniation through the transverse mesocolon. In a series of more than 1000 cases, Higa and colleagues reported the most common complications to be stenosis at the gastrojejunostomy (4.9%), internal hernia (2.5%), marginal ulcer (1.4%), and staple-line leaks (1%). The overall mortality in that series was 0.5%.

The early results of LRYGBP compare favorably with open RYGBP. Most notable is the reduced rate of cardiopulmonary and wound-related complications. Nguyen et al showed in a randomized trial that during the first 3 postoperative days patients who underwent LRYGBP had significantly less pulmonary impairment than did the patients who underwent open bypass surgery. In addition, fewer patients developed hypoxemia after LRYGBP than after open surgery (31% vs 76%, P < .001). Only 6% of the patients who underwent laparoscopic procedures developed segmental ileus on the first postoperative day, compared with 55% of the patients in the open bypass group (P = .003). Wound-related complications, including infections and hernias, are virtually nonexistent after laparoscopic gastric bypass surgery. Contemporary data on recovery after open RYGBP are elusive; however, a fair estimate is at least 6 to 12 weeks before the patient is able to return to normal activities. The recovery after LRYGBP seems to be half as long. The mortality rate (0%-0.4%) after LRYGBP is comparable to that of the open bypass approach.

**LBPD AND DUODENAL SWITCH**

Laparoscopic approaches to malabsorption procedures such as the biliopancreatic diversion, the duodenal switch operation (Figure 4), or distal gastric bypass are more complex and technically difficult. These malabsorption procedures compose fewer than 15% of all bariatric operations performed in North America. These procedures allow patients to maintain unrestricted eating patterns and result in effective weight loss but carry a

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**Table 4. Selected Large Laparoscopic Roux-en-Y Gastric Bypass Series**

<table>
<thead>
<tr>
<th>Source</th>
<th>Total No. of Patients</th>
<th>Female, %</th>
<th>BMI*</th>
<th>Mean Length of OR Time, min</th>
<th>Conversion Rate, %</th>
<th>Complication Rate, %</th>
<th>Mean Length of Hospital Stay, d</th>
<th>Mortality, %</th>
<th>Length of Follow-up, mo</th>
<th>Type of Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilfong and Clark, 1999</td>
<td>500</td>
<td>Nl</td>
<td>Nl</td>
<td>120</td>
<td>Nl</td>
<td>10.4</td>
<td>2.2</td>
<td>2.6</td>
<td>Nl</td>
<td>60</td>
</tr>
<tr>
<td>Schauer et al, 2000</td>
<td>275</td>
<td>81</td>
<td>48</td>
<td>247</td>
<td>1.0</td>
<td>3.3</td>
<td>27.0†</td>
<td>2.6</td>
<td>0.4</td>
<td>30</td>
</tr>
<tr>
<td>Higa et al, 2001</td>
<td>1500</td>
<td>81</td>
<td>35-70</td>
<td>50-75</td>
<td>Nl</td>
<td>2.3</td>
<td>12.5</td>
<td>1.5</td>
<td>0.2</td>
<td>35</td>
</tr>
<tr>
<td>Delmaria et al, 2002</td>
<td>281</td>
<td>87</td>
<td>48.3</td>
<td>162</td>
<td>2.8</td>
<td>7.3</td>
<td>16.8</td>
<td>4.0</td>
<td>0.2</td>
<td>12</td>
</tr>
<tr>
<td>Gould et al, 2002</td>
<td>223</td>
<td>90</td>
<td>49</td>
<td>127</td>
<td>4.7</td>
<td>10.2</td>
<td>6.4</td>
<td>4.7</td>
<td>0.1</td>
<td>12</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; EWL, excess weight loss; Nl, not indicated; OR, operating room.

*The BMI is calculated as the weight in kilograms divided by the height in meters squared.
†In this series, 13% had BMI values between 40 and 42, 22% had BMI values between 35 and 39, 60% had BMI values between 30 and 35, and 5% had BMI values between 60 and 78.
higher risk of nutritional complications such as protein malnutrition and vitamin deficiencies. Because of higher long-term risks some surgeons prefer to reserve the malabsorption procedures for select groups of refractory patients, that is, those with a BMI exceeding 60 or those who have failed other weight loss operations.

The results of 4 studies of laparoscopic malabsorptive procedures have been published to date. These studies have investigated either the LBPD or the duodenal switch (Table 5).85–90 The conversion rate and the operative times varied widely depending on the surgeon’s experience. Major morbidity was reported to be 7.5% to 15.0%; mortality was from 0% to 2.5%. Weight loss was comparable to open BPD at 1 year in 3 of the studies.87–90 These studies collectively demonstrate that LBPD and the duodenal switch are feasible with a reasonable perioperative morbidity and mortality in the appropriate populations. Presently, only preliminary data are available; further long-term outcome-based studies with larger sample populations are required before these procedures can be widely recommended.

HAND-ASSISTED LAPAROSCOPIC BARIATRIC SURGERY

The large technical hurdles involved in laparoscopic bariatric surgery have led some surgeons to adopt hand-assisted modifications.91–94 Laparoscopic vertical banded gastroplasty and LRYGBP have both been performed with hand-assisted techniques although experience is limited.93–97 The results of all recent series96–98 showed faster recovery rates after hand-assisted LVBG compared with the recovery rates of subjects who underwent open or those of historic control subjects. All but 2 studies reported a relatively high staple-line leakage rate early in their series of 4% to 6%98,101 and a 12% to 20% hernia rate at 1 year at the hand port site. DeMaria et al99 concluded that despite the increased cost, the hand-assisted approach may be valuable in bariatric surgery in the following 5 areas: (1) to repair a concomitant ventral hernia, (2) to salvage a total laparoscopic case, (3) to use when a skilled assistant for a total laparoscopic approach is unavailable, (4) to use in a patient with a high BMI, and (5) to aid the surgeon’s learning curve in acquiring the skills to do the total laparoscopic approach.

TRAINING ISSUES FOR LAPAROSCOPIC BARIATRIC OPERATIONS

Laparoscopic bariatric surgery is technically challenging because it requires unique skills that surgeons do not gain with traditional, more common laparoscopic procedures. Additionally, obesity-related factors and the complexity of these reconstructive procedures create major technical barriers. These barriers may translate into steep learning curves for surgeons, longer initial operating times, potentially higher rates of perioperative compli-

![Figure 4. View of completed laparoscopic biliopancreatic diversion with duodenal switch. (Reprinted from Schauer P, Hamad G, Ikrar H. Surgical management of gastroesophageal reflux disease in obese patients. Semin Laparosc Surg. 2001;8:258-264, with permission from Elsevier.)](image)

<table>
<thead>
<tr>
<th>Table 5. All Laparoscopic Malabsorptive Procedure Series</th>
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</thead>
<tbody>
<tr>
<td>Source</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Ren et al.86 2000</td>
</tr>
<tr>
<td>Patna et al.86 2002</td>
</tr>
<tr>
<td>Scopinaro et al.94 2002</td>
</tr>
<tr>
<td>Baltasar et al.96 2002</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; BPD, biliopancreatic diversion; DS, duodenal switch; EWL, excess weight loss; NI, not indicated; OR, operating room.

*The BMI is calculated as the weight in kilograms divided by the height in meters square.
cations, and a high rate of conversion. The surgeon's learning curve for laparoscopic gastric bypass surgery seems to be steep compared with other advanced laparoscopic procedures. Acquisition of advanced laparoscopic skills is essential for safe and efficient performance of any laparoscopic bariatric operation. It is critical that surgeons interested in performing laparoscopic bariatric operations prepare for these advanced procedures. Short introductory courses with didactics and hands-on experience can be helpful, but they are the beginning and not the end of preparation. Animal laboratory experience and proctoring by an experienced surgeon are highly recommended. Equally important to laparoscopic skill development is the acquisition of bariatric surgery practice management skills, especially for surgeons entering the field of bariatric surgery. Guidelines for establishing a bariatric surgery program published by the American College of Surgeons, the American Society for Bariatric Surgery, and the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) are highly recommended for those interested in performing open or laparoscopic operations.

**SUMMARY**

Minimally invasive approaches to bariatric surgery offer significant advantages over those of open surgery. Early results of LBG suggest a significant decrease in perioperative morbidity compared with the open approach, yet there seems to be less overall enthusiasm in adoption of this technique. An LAGSB may have the lowest perioperative morbidity and mortality of all current bariatric operations. However, it does seem to have a significant reoperation rate for device-related complications, which may be related to the experience of the surgeon. Intermediate-term weight loss for LAGSB seems to be good (50%-55% of estimated weight loss), but some patients (ie, those who are classified as super obese) may achieve less weight loss. Findings from outcomes-based studies of LRYGBP are accumulating and suggest that it is feasible, safe, and delivers weight loss equivalent to that found with open surgical methods. The LRYGBP is associated with relatively low perioperative morbidity, short hospital stay, and rapid recovery compared with an open RYGBP. Thus, for patients in the United States, demand for LRYGBP seems to exceed that of the open approach. The value of hand-assisted bariatric procedures and LAPB procedures must await further study. The laparoscopic era of bariatric surgery has arrived.

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Correction

Numerical Error. In the Special Article by Cotumet al published in the April
issue of the ARCHIVES (2003;138:367-375), the value of the second entry in Table 2
on page 372 under the column titled "Mean Length of Hospital Stay, d" should
have been 3.6 rather than 2.6.