Pulmonary function and pain after gastroplasty performed via laparotomy or laparoscopy in morbidly obese patients†

J. L. JORIS, V. L. HINQUE, P. E. LAURENT, C. J. DESAIVE AND M. L. LAMY

Summary

We have compared severely obese patients (body mass index > 35 kg m⁻²) undergoing laparoscopic or open gastroplasty (n = 15 in each group) to determine if laparoscopy results in any benefit in the obese. Postoperative pain, measured on a 100-mm visual analogue scale, and opioid consumption were recorded during the first two days after operation. Tests of pulmonary function were performed and on days 1, 2 and 3 after operation. Pain at rest was similar in the two groups, but in the laparoscopy group, requirements for postoperative opioid were 50% less (P < 0.05). Pain intensity during mobilization and on coughing was significantly less after laparoscopy (differences between mean pain scores in both groups ranged from 20 to 32 mm during mobilization and from 32 to 34 mm during coughing). Forced vital capacity, forced expiratory volume in 1 s and peak expiratory flow rate were reduced significantly less after laparoscopic gastroplasty than after open gastroplasty (on day 1 forced vital capacity was reduced by 50% compared with 64%, forced expiratory volume in 1 s was reduced by 50% compared with 66% and peak expiratory flow rate by 45% compared with 60%). SpO₂ values were significantly greater in the laparoscopy group (day 1: mean 95 (sd 2) % vs 91 (5) %; day 3: 97 (1) % vs 94 (3) %). This study suggests that the beneficial effects observed after laparoscopic gastroplasty in morbidly obese patients were similar to those reported after laparoscopic cholecystectomy in non-obese patients. (Br. J. Anaesth. 1998; 80: 283–288)

Keywords: lung, function; complications, obesity; pain, post-operative; surgery, laparoscopy; surgery, laparotomy

Obesity results in multiple pathophysiological disturbances, including cardiovascular, respiratory, gastrointestinal, metabolic and pharmacological changes. These changes complicate perioperative anaesthetic and surgical management of obese patients. Consequently, postoperative morbidity and mortality are higher in obese than in non-obese patients. Obesity significantly increases the risk of postoperative hypoxaemia and pulmonary complications, particularly after upper abdominal surgery. These observations are clinically relevant as up to 23% of the population in Europe and 33% in the USA is obese, and almost 5% of the USA population weigh more than twice their ideal body weight. Furthermore, morbidly obese patients are frequently scheduled for abdominal surgery, such as gastroplasty, to treat diet-resistant obesity.

Laparoscopic cholecystectomy results in less postoperative pulmonary dysfunction, faster recovery of preoperative pulmonary function and less atelectasis than open laparotomy. Postoperative pain or opioid requirements, or both, are also reduced after laparoscopy. All of these postoperative benefits facilitate early chest physiotherapy, mobilization and ambulation, which may be particularly beneficial for obese patients. Laparoscopic cholecystectomy, initially considered to be contraindicated in obese patients for technical reasons, is now performed regularly in these patients and is associated with similar postoperative clinical benefits to those reported in non-obese patients. These include earlier resumption of diet, reduced duration of hospitalization and fewer complications compared with laparotomy. Nevertheless, the benefits of laparoscopy on postoperative pulmonary dysfunction may be less in obese patients. Indeed, we observed that pulmonary function tests in morbidly obese patients after open gastroplasty were affected to a greater degree than in non-obese patients after open cholecystectomy. Similarly, Johnson and colleagues reported that improvement in postoperative pulmonary restrictive syndrome observed after laparoscopy might be less in obese than in non-obese patients. However, they included only eight moderately obese patients. To our knowledge, no studies have explored the pathophysiologial changes after laparoscopy in morbidly obese patients.

The laparoscopic approach has now been extended to gastroplasty. Therefore, we compared prospectively postoperative pain and pulmonary function after gastroplasty performed via laparoscopy or laparotomy in severely and morbidly obese patients, to determine the potential benefits of the laparoscopic approach compared with the open procedure.
Patients and methods

The study was conducted after obtaining approval from our institution’s Ethics Committee and informed consent from all patients. We studied 15 consecutive patients undergoing elective laparoscopic gastroplasty and 15 undergoing open gastroplasty. These patients had suffered severe obesity (body mass index (BMI) greater than 35 kg m\(^{-2}\)) for more than 5 yr and were resistant to dietary treatment under medical control. None of these patients had cardiac or intrinsic pulmonary disease.

We used the same anaesthetic technique in all patients. Anaesthesia was induced with clonidine 0.3 mg i.v. given over 10 min, propofol 2 mg kg\(^{-1}\) i.v. and sufentanil 20 \(\mu\)g i.v. Orotracheal intubation was facilitated by succinylcholine 1 mg kg\(^{-1}\). General anaesthesia was maintained with isoflurane and 50% nitrous oxide in oxygen. Intraoperative neuromuscular block was produced with atracurium. At the end of surgery, residual neuromuscular block was antagonized with neostigmine 2.5 mg and atropine 1 mg.

Open gastroplasty consisted of reduction of the stomach with creation of a small pouch using four vertical rows of staples associated with a silastic ring, as described by Laws.21 Gastric resection was not performed. Gastroplasty was performed via a midline incision extending from the xiphoid notch to the umbilicus. In the laparoscopy group, an adjustable silicone gastric band (Inamed, Breda, The Netherlands) was used to create a small upper gastric pouch of 15 ml in volume.20 The surgical approach (laparotomy vs laparoscopy) was determined by the patient’s acceptance of the laparoscopic technique and agreement by the patient to pay for the silicone band used for laparoscopic gastroplasty. It should be noted that in Belgium, laparoscopic gastroplasty costs patients three times more than laparotomy. No patient in either group had a nasogastric tube after operation.

POSTOPERATIVE ANALGESIA

All patients received the same postoperative analgesic therapy: i.v. patient-controlled analgesia (PCA) with piritramide, a synthetic opioid (Dipidolor, Janssen Pharmaceutica, Beerse, Belgium) combined with i.v. administration of propacetamol, a precursor of paracetamol, 2 g every 6 h (Prodafalgan; UPSA Medica, Brussels, Belgium: propacetamol 2 g = paracetamol 1 g). PCA settings were: bolus dose = piritramide 1 mg, lockout interval = 5 min, maximum dose = 20 mg every 4 h; no continuous infusion was used. Patients were instructed before operation in the use of the PCA pump. Pain scores were recorded on a 100-mm visual analogue scale at rest, during mobilization (patients were asked to move from the supine to the sitting position) and on coughing. Pain intensity was measured 4 h after surgery, at 08:00, 13:00 and 18:00 on day 1, and at 08:00 on day 2 after operation. Postoperative piritramide consumption was measured every 4 h until 40 h after operation.

PULMONARY FUNCTION

Pulmonary function testing was performed in the sitting position by the same technician who was blinded to the patient allocation group, on the day before surgery, 4 h after surgery and on days 1, 2 and 3 after operation. The following variables were recorded: forced vital capacity (FVC), forced expiratory volume in 1 s (FEV\(_1\)) and peak expiratory flow rate (PEFR). These variables were measured using a Microlab 3000 series bedside spirometer (Micro Medical Ltd, Rochester, England). Capillary haemoglobin oxygen saturation \(S\_O_2\) was also measured using a Datex Cardiocap pulse oximeter (Datex, Helsinki, Finland) after breathing room air for 15 min. Patients in both groups had the same regimen of chest physiotherapy combined with incentive spirometry after operation.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient data, duration of surgery (mean (SD or range) or number) and duration of hospital stay (median [range]) in patients undergoing laparoscopic or open (laparotomy) gastroplasty. *(P &lt; 0.05) compared with laparotomy group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laparoscopy group</td>
</tr>
<tr>
<td>Age (yr) (mean (range))</td>
<td>33 (23–44)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>113 (14)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166 (6)</td>
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<tr>
<td>Body mass index (kg m(^{-2}))</td>
<td>41.2 (5.2)</td>
</tr>
<tr>
<td>Sex (F/M)</td>
<td>14/1</td>
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<tr>
<td>Duration of surgery (min)</td>
<td>137 (39)*</td>
</tr>
<tr>
<td>Smoker (Y/N)</td>
<td>10/5</td>
</tr>
<tr>
<td>Postop. hospital stay (days)</td>
<td>4 [4–5]</td>
</tr>
</tbody>
</table>

![Figure 1](image_url)
Results are reported as mean (SD). Data were analysed by two-way analysis of variance followed by Scheffé’s test. Patient data were compared using the unpaired Student’s \( t \) test or the Mann–Whitney test, where appropriate. Results were considered statistically significant at the 5% critical level.

Results

Patient characteristics and duration of hospital stay were similar in the two groups. Nine patients in the laparoscopy group and 11 patients in the laparotomy group had a BMI greater than 40 kg \( m^2 \). Duration of surgery was significantly longer in the laparoscopy than in the laparotomy group (table 1).

Pain intensity at rest, during mobilization and on coughing decreased significantly over time in both groups after surgery. Pain scores at rest were similar in the two groups, except at 18:00 on day 1 when patients in the laparotomy group reported significantly more pain than those in the laparoscopy group. Pain during mobilization and on coughing was significantly more intense in the laparotomy group throughout the study (fig. 1). Opioid consumption was significantly reduced in the laparoscopy group as early as 4 h after surgery (fig. 2).

Interestingly, whereas opioid consumption decreased significantly over time after laparoscopy, a significant increase in opioid consumption was observed in the laparotomy group 20 h after surgery, which corresponded to the morning of the first day after operation.

FVC, FEV\(_1\) and PEFR decreased significantly in the two groups after operation. However, FVC, FEV\(_1\) and PEFR were significantly higher in the laparoscopy group than in the laparotomy group at each time after surgery. Furthermore, the rate of recovery towards preoperative values for these three variables was significantly faster in the laparoscopy group, particularly for FEV\(_1\) and PEFR (fig. 3). \( \text{SpO}_2 \) values were significantly decreased in both groups 4 h after surgery and on the first day after operation. However, the laparoscopy group had a significantly higher mean \( \text{SpO}_2 \) on the first and third days after operation (fig. 4).

Discussion

This study has demonstrated that laparoscopic gastroplasty resulted in less postoperative pain, reduced opioid consumption and less postoperative pulmonary dysfunction compared with open gastroplasty. These findings suggest that severely (BMI 35–40 kg \( m^2 \)) and morbidly (BMI 40–50 kg \( m^2 \)) obese patients benefit from similar advantages after laparoscopy to those observed in non-obese patients.

Pain at rest did not differ between the two groups except at 18:00 on the first day after operation. Indeed, as patients in both groups were provided with PCA, they could titrate opioid administration to
obtain similar levels of presumably satisfactory analgesia at rest. However, opioid requirements to reach this level of analgesia were significantly less after laparoscopy. After laparotomy, continual stimulation of the abdominal wall incision results in persistent pain and consequently greater opioid consumption. Patients, although in bed for the first 20 h after operation, were more mobile and active on day 1, leading to increased nociception. Accordingly, an increase in opioid consumption was observed in the laparotomy group 20 h after operation. Conversely, laparoscopy does not involve a large surgical incision and spares the abdominal wall the trauma of surgical retractors. Consequently, parietal pain is reduced after laparoscopy and is also more short-lived. 22 Moreover, movement, coughing and ambulation result in less pain, and opioid consumption continues to decrease on day 1. The reduction in opioid consumption observed after laparoscopy is particularly useful in obese patients who are thought to be more sensitive to the side effects of opioid analgesia than non-obese patients. 1

The pathogenesis of postoperative pulmonary restrictive syndrome seen after laparotomy includes several factors, such as the site and size of incision, 23, 24 postoperative pain 23, 25 and diaphragmatic dysfunction. 26, 28 Abdominal wall trauma and postoperative pain are reduced significantly after laparoscopy. 8, 11, 13 Moreover, diaphragmatic impairment is also less after laparoscopy than after laparotomy. 29, 31 Consequently, laparoscopy results in less postoperative pulmonary dysfunction. 7–12 Our study showed that the reduction in pulmonary dysfunction reported after laparoscopy in non-obese patients is also present in severely and morbidly obese patients. This effect was observed despite longer surgical times in the laparoscopy group. Furthermore, the slopes of the recovery curves for FVC, FEV1 and PEFR were steeper in the laparoscopy group than in the laparotomy group. The faster recovery to preoperative values may result from differences in pain characteristics after these two surgical approaches. Parietal pain, which affects effort-dependent spirometric volumes is not only less intense, but more short-lived after laparoscopy than laparotomy. 7, 22 Similarly, duration of diaphragmatic dysfunction also seems to be shorter after laparoscopy. 30, 31 Moreover, the reduction in pain and opioid consumption observed after laparoscopy may facilitate chest physiotherapy, early mobilization and ambulation, all of which help to prevent the development of postoperative atelectasis and secondary hypoxaemia. 32–34

This study has confirmed that pulmonary function tests after open upper abdominal surgery were affected to a greater degree in obese 39 than in non-obese patients. 7–12 Similarly, the decrease in pulmonary volumes measured after laparoscopy in our obese patients were greater than those reported in non-obese counterparts. 7–12 Several mechanisms may contribute to the more severe postoperative pulmonary restrictive syndrome observed in obese patients. Obesity is associated with reduced functional residual capacity. 35 The magnitude of the decrease in functional residual capacity required for spontaneous ventilation to decrease within the closing volume is, therefore, less in obese than in non-obese patients. 4, 36 As a consequence, the postoperative decrease in lung volumes is more likely to result in gas trapping, atelectasis and hypoxaemia. Even small postoperative changes may produce more significant effects in these patients. Diaphragmatic dysfunction is one of the main determinants of the postoperative restrictive syndrome. 36, 27 Because of reduced thoracopulmonary compliance in obese patients, 37 the pressure gradient generated by impaired diaphragmatic contraction (even if similar in obese and non-obese patients) would result in mobilization of smaller lung volumes. Finally, respiratory muscle work load is increased and the efficiency of breathing is decreased in obese patients. 38 Postoperative fatigue would further aggravate these pathophysiological changes and impair muscle performance. 39 Lung volumes measured by spirometry would be reduced in obese compared with non-obese patients. Nevertheless, the rate of improvement in pulmonary function observed after laparoscopy (relative to that seen after laparotomy) in the morbidly obese patient is clinically significant, as $S_{\text{Po}_2}$ values were significantly higher after laparoscopy than after laparotomy. Our study was not designed to reveal any benefit of laparoscopy on the incidence of postoperative pulmonary complications in morbidly obese patients. Therefore, we did not perform postoperative chest x-ray. This important clinical issue deserves to be investigated.

We do not believe that the benefits observed in the laparoscopy group resulted from differences in socio-economic class or from different levels of patient motivation between the two groups. Indeed, approximately 80–90% of the obese patients from both groups belonged to the lower socio-economic classes, as has been reported previously. 5 Although the cost difference between the two surgical approaches did not allow us to perform a randomized study, agreement to pay for the silicone band was not the primary indication for selection of surgical technique. This study was conducted soon after the development of laparoscopic gastroplasty, while the open procedure was still more popular and performed more frequently than laparoscopic surgery. Many obese patients were persuaded to choose open gastroplasty by relatives who successfully underwent this procedure, or after information received from various associations of morbidly obese patients.

Figure 4 Capillary haemoglobin oxygen saturation $S_{\text{Po}_2}$ (mean (sd)) after laparoscopic or open gastroplasty. *P < 0.05 compared with the laparotomy group.
Several dietary treatments had already failed in these patients, who had suffered severe obesity for more than 5 yr. For all of these reasons, motivation was high in each patient, and was similar in the two groups.

This study was carried out 6 months after the introduction of laparoscopy for gastroplasty in our institution. The surgical team was therefore still learning this laparoscopic procedure. With experience, a reduction in duration of surgery and surgical trauma can be expected. Consequently, the magnitude of the benefits observed after laparoscopic gastroplasty on postoperative pain and pulmonary dysfunction may be increased further. Because hospital stay after gastroplasty is standardized and dependent mainly on patient adaptation to the small gastric pouch, we did not observe a significant effect of laparoscopy on this variable. Further studies are necessary to compare postoperative weight loss and the incidence of early and late surgical complications after these two surgical approaches.

In summary, severely and morbidly obese patients undergoing laparoscopic gastroplasty had significantly less postoperative pain, required less opioid and had better pulmonary function after operation compared with conventional open gastroplasty. All of these benefits are particularly welcome in these patients who are at high risk of developing postoperative pulmonary complications.

References


