Laparoscopic versus Open Obesity Surgery: A Meta-Analysis of Pulmonary Complications

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Key Words

Obesity · Laparoscopy · Pulmonary · Complication · Pneumonia · Morbidity

Abstract

The clinical effects of laparoscopy in the pulmonary function of obese patients have been poorly investigated in the past. A systematic review was undertaken, with the objective to identify published evidence on pulmonary complications in laparoscopic surgery in the obese. Outcome measures included pulmonary morbidity, pulmonary infection and mortality. The random effects model was used to calculate combined overall effect sizes of pooled data. Data are presented as the odds ratio (OR) with 95% confidence interval (CI). A total of 6 randomized and 14 observational studies were included, which reported data on 185,328 patients. Pulmonary complications occurred in 1.6% of laparoscopic and in 3.6% of open procedures (OR 0.45, 95% CI 0.34–0.60). Pneumonia was reported in 0.5% and in 1.1%, respectively (OR 0.45, 95% CI 0.40–0.51). Available evidence suggests lower pulmonary morbidity for laparoscopic surgery in obese patients; further quality studies are however necessary to consolidate these findings.

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Introduction

Obesity is strongly associated with the impairment of several components of the respiratory function [1]. Mechanical and physiopathologic factors are implicated in decreased tidal and lung volumes and higher respiratory rates, whereas other components of the respiratory function remain virtually unchanged [2]. General anesthesia and abdominal surgery challenge the physiological respiratory function in obese patients [3, 4]. The incidence of clinically relevant or asymptomatic atelectasis is increased [5], whereas obesity has been recognized as an independent factor for adverse respiratory events in the postoperative period [6]. The variety of investigated anesthetic maneuvers to retain normal pulmonary function is indicative of the difficulty in managing these patients in the intraoperative and early postoperative period [7–11].

Minimization of surgical trauma by the use of laparoscopic techniques has led to a decrease in pulmonary complications in surgical procedures of the upper abdomen [12, 13]. Despite these beneficial effects of laparoscopy in non-obese patients, these may be less pronounced in the presence of obesity [14]. Higher intraabdominal pressures are usually required, in order to provide ade-

quate laparoscopic view; they adversely affect the pulmonary function due to decreased compliance of the diaphragm [15–17]. The use of additional muscle relaxants is common and represents an additional risk factor for acute respiratory events in the postoperative period [18].

This study aimed to investigate the incidence of clinical pulmonary respiratory events following laparoscopic or open surgery in obese patients. A preliminary systematic search of the literature indicated that there is limited comparative evidence on procedures other than bariatric. The investigation was thus focused exclusively on bariatric surgery, and the comparative outcomes of the laparoscopic and the open approach in terms of pulmonary morbidity and mortality.

Materials and Methods

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement standards and the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) recommendations [19, 20]. A structured protocol was conducted by the two primary authors, defining the research question, the outcome measures, the inclusion and exclusion criteria, the search methodology, and quality and reporting assessment tools of the included studies.

Outcome Parameters

The overall incidence of pulmonary complications was the primary outcome measure of treatment effect. Secondary outcome measures included the incidence of pneumonia, pleural effusion, atelectasis and death.

Inclusion and Exclusion Criteria

Studies comparing a common bariatric procedure through the laparoscopic or the open approach were included. The reported minimum body mass index (BMI) had to be 30 kg/m², and the study protocol had to include adult patients. Studies not reporting on minimum BMI, not comprising similar and homogeneous procedures, and those not reporting on any of the primary outcome measures were excluded. Corresponding authors of studies which did not report on minimum BMI were contacted by e-mail and were requested to provide this information.

Search Methodology

The MEDLINE database was searched using the Pubmed platform from inception up to October 2013. The keywords 'laparoscopic' OR 'open' OR 'conventional' AND 'obese' OR 'obesity' OR 'bariatric' OR 'body mass index' OR 'BMI' AND 'complications' OR 'morbidity' OR 'pulmonary' OR 'respiratory' OR 'pneumonia' OR 'chest infection' OR 'atelectasis' OR 'pleural effusion' were used. The search was limited to records written in the English or German and providing an abstract. The first-level screening included the titles and summaries; if a publication was considered to meet the inclusion criteria, the full text was obtained for a second-level screening. If the full text could not be accessed, the corresponding author was contacted by e-mail and was requested to

provide an electronic reprint of the article. The primary author performed the first-level search; two authors independently screened and extracted data from the full records.

Data Extraction

Relevant information from each article was entered in a pre-structured electronic database, based on the Cochrane Consumers and Communication Review Group's data extraction template, which was pilot-tested on the three most recent studies and refined accordingly. The following data were extracted: name of the primary author, year of publication, primary center performing the investigation, patient recruitment period, study design, absolute number of patients assigned to the laparoscopic or the open procedure, mean or median age, mean or median BMI, surgical procedure, duration of follow-up, intention-to-treat or as-treated analysis, and the outcome measures, as defined.

Assessment of Methodological and Reporting Quality

Randomized trials were subjected to methodological quality assessment using the Cochrane Collaboration's Tool for assessing risk of bias [21]. This tool considers the sequence generation, allocation concealment, blinding of participants, personnel, and outcome assessors, inadequately reported or missing outcome data, selective outcome reporting, and other potential threats to validity.

The quality of observational studies was assessed using the Newcastle-Ottawa Quality Assessment Scale for case control studies or cohort studies (as applicable) [22]. This tool evaluates three main methodological elements of case-control studies: selection methods (adequate case definition, representativeness of the cases, appropriate selection and definition of controls), comparability of cases and controls on the basis of the design or analysis, and assessment of exposure (ascertainment of exposure, non-response rate). The scale uses a star system, with a maximum of nine stars.

Methods of Analysis

Individual study odds ratios (ORs) and 95% confidence intervals (CIs) were calculated from event numbers extracted from each study before data pooling. Summary estimates of ORs were obtained with a random effects model according to DerSimonian and Laird [23]. Heterogeneity was assessed using the I² statistic, a method expressing the percentage of variation across studies. I² values between 0 and 25% suggest low level, values above 25% suggest moderate level, and values above 75% suggest high level of heterogeneity. Publication bias was assessed visually evaluating the symmetry of funnel plots. Statistical analysis was performed using RevMan (Review Manager 5.2, The Nordic Cochrane Centre, Copenhagen, Denmark). Formal statistical expertise was provided by one of the study authors (G.A.A.).

Results

Search Results

The search of the electronic databases identified 1,520 unique records. Some 1,407 articles were excluded on the basis of their title or abstract not being relevant, leav-

ing 113 articles for full text review. Five articles could not be retrieved from national and international libraries and the corresponding authors did not respond to our request for the full record. Eighteen articles did not report on the BMI of the study population. The authors were contacted and were asked to provide additional relevant information. Twelve authors responded and provided relevant data; nine studies fulfilled the inclusion criteria and were included in the analysis. A total number of 20 articles entered the meta-analysis models (fig. 1) [24–43].

Study Characteristics

An overview of characteristics of the included studies is presented in table 1. All articles were published in the English language and publication time ranged between 1999 and 2012. A total of 185,328 patients were included in 6 randomized trials, 3 prospective and 10 retrospective observational studies, whereas design characteristics were not defined in one report. In three studies, patient data and outcomes were recruited from large prospectively designed databases. Roux-en-Y gastric bypass was the most common procedure and was reported in 16 studies. Outcomes were reported on an intention-to-treat basis in 10 studies, as-treated analysis was followed in 2 studies, whereas 8 studies did not provide relevant information (data not shown). Pleural effusion was not reported in any study and atelectasis was reported only by one study, which precluded pooled analysis.

Quality Assessment

Methodological quality of randomized trials was in general adequate, although 2 studies only reported on appropriate blinding of patients and assessors and 4 reported on valid sequence generation (quality assessment of randomized trials available upon request). Observational studies were of moderate quality, with a median of 5 stars (range 3–7).

Synthesis of Data

Pulmonary complications occurred in 1.6% of laparoscopic and in 3.6% of open procedures (OR 0.45, 95% CI 0.34–0.60). A moderate level of heterogeneity was evident, and the possibility of publication bias was high (fig. 2, 3).

Pulmonary infection was reported in 0.5 and in 1.1% of laparoscopic and open procedures, respectively (OR 0.45, 95% CI 0.40–0.51). No evidence of heterogeneity existed, whereas the possibility of publication bias was low (fig. 4, 5).

Fig. 1. Search history and selection of studies.

All-cause mortality was 0.1% in the laparoscopic group and 0.4% in the open group (OR 0.35, 95% CI 0.20–0.62). There was no evidence of between-study heterogeneity or publication bias (fig. 6, 7). A summary of individual study outcomes is provided in table 2.

Sensitivity Analysis

Outcome data from large population-based studies were excluded [34, 36, 43], in order to reduce selection bias. ORs were constantly in favor of laparoscopy (OR for pulmonary complications 0.49, 95% CI 0.32–0.75; OR for pneumonia 0.45, 95% CI 0.15–1.33; OR for mortality 0.41, 95% CI 0.16–1.10), although statistical significance was reached only for pulmonary complications.

Table 1. Study characteristics

Author, year	Period of recruitment	Study design	No. of patients	Laparoscopic	Open	BMI	Surgical procedure	NOS stars
Azagra, 1999 [24]	1995–1996	RCT	68	34	34	mean 43	VBG	NA
Bleier, 2000 [25]	1998–1999	Prospective	92	46	46	mean 55.0±1.6 lap, 50.4±1.4 open	VBG	3
Nguyen, 2000 [26]	1992–1999	Retrospective	70	35	35	mean 51±6 lap, 48±6 open	RYGB	5
Nguyen, 2001 [27]	1999–2000	RCT	70	36	34	mean 48±5 lap, 50±5 open	RYGB	NA
Nguyen, 2001 [28]	1999–2001	RCT	155	79	76	mean 47.6±4.7 lap, 48.4±5.4 open	RYGB	NA
Courcoulas, 2003 [29]	1999–2002	NR	160	80	80	mean 44 lap, 46 open	RYGB	3
Kim, 2003 [30]	1999–2001	Retrospective	54	26	28	mean 66.9±7.5 lap, 68.8±10.1 open	BPD-DS	7
Luján, 2004 [31]	1999–2002	RCT	104	53	51	median 48.5 (range 36–78) lap, 52.2 (range 37–80) open	RYGB	NA
Smith, 2004 [32]	2000–2002	Retrospective	779	328	451	mean 46.7 lap, 49.5 open	RYGB	6
Sundbom and Gustavsson, 2004 [33]	2000–2002	RCT	20	25	25	median 44 (range 36–54) lap, 45 (range 34–54) open	RYGB	NA
Hutter, 2006 [34]	2000–2003	Prospective database*	1,356	401	955	mean 47.5 lap, 50.5 open	RYGB	5
Campos, 2007 [35]	2003–2006	Prospective	404	332	72	median 48 (range 35–103)	RYGB	6
Nguyen, 2007 [36]	2004–2006	Prospective database [†]	22,422	16,357	6,065	NR	RYGB	5
Agaba, 2008 [37]	1998–2004	Retrospective	1,367	806	561	mean 46.2±4.7 lap, 47.6±5.7 open	RYGB	6
Benotti, 2009 [38]	2006–2006	Retrospective	881	415	446	mean 48.7±5.6 lap, 53.6±9.0 open	RYGB	6
Kim, 2009 [39]	1995–2006	Retrospective	752	488	264	mean 54.2±10.4	RYGB	5
Barbalho-Moulim, 2011 [40]	NR	Prospective	26	13	13	mean 39.7±3.9 lap, 40.7±4.3 open	RYGB	4
de Wit, 1999 [41]	1995–1997	RCT	50	25	25	mean 51.3±10.4 lap, 49.7±5.6 open	AGB	NA
Skroubis, 2011 [42]	1994–2008	Retrospective	227	137	90	mean 46.4±3.3 lap, 45.6±5.2 open	RYGB	6
Banka, 2012 [43]	2005–2007	Prospective database [‡]	156,271	115,117	41,094	NR	RYGB	5

BMI = Body mass index; NOS = Newcastle-Ottawa scale; RCT = randomized controlled trial; NR = not reported; NA = not applicable; lap = laparoscopic; VBG = vertical banded gastroplasty; RYGB = Roux-en-Y gastric bypass; BPD-DS = biliopancreatic diversion with duodenal switch; AGB = adjustable gastric banding.

* National Surgical Quality Improvement Program of the American College of Surgeons (ACS-NSQIP); [†] University Health System Consortium; [‡] Nationwide Inpatient Sample.

Fig. 2. Forest plot of odds ratios for pulmonary complications.

Fig. 3. Funnel plot for pulmonary complications.

Discussion

This systematic literature analysis aimed primarily to assess pulmonary morbidity in laparoscopic and open surgery, on the basis of the ambiguous effects of laparoscopy on the pulmonary function in obese patients. The volume of relevant data outside the field of obesity surgery was surprisingly scarce, which prompted the research team to modify the study protocol and focus exclusively on operations for obesity. The objective was to

minimize systematic bias related to the spectrum of upper and lower gastrointestinal surgery. Heterogeneity was reduced to some extent, since all studies assessed upper gastrointestinal operations and 16 articles included only Roux-en-Y bypass procedures. Because the main body of data derives from observational studies with study groups of heterogeneous demographical data, the random-effects model was applied to decrease the possibility of overestimating treatment effects. Nevertheless, selection bias introduced by the retrospective and open-label study

Fig. 4. Forest plot of odds ratios for pneumonia.

Fig. 5. Funnel plot for pneumonia.

Fig. 6. Forest plot of odds ratios for mortality.

Fig. 7. Funnel plot for mortality.

Table 2. Study outcomes

Author, year	Pulmonary complications		Pneumonia		Mortality	
	lap	open	lap	open	lap	open
Azagra, 1999 [24]	NR	NR	1/34	0/34	0/34	0/34
Bleier, 2000 [25]	4/46	19/46	0/46	1/46	NR	NR
Nguyen, 2000 [26]	1/35	1/35	NR	NR	0/35	0/35
Nguyen, 2001 [27]	0/36	1/34	0/36	0/34	NR	NR
Nguyen, 2001 [28]	0/79	1/76	NR	NR	0/79	1/76
Courcoulas, 2003 [29]	NR	NR	1/80	0/80	0/80	1/80
Kim, 2003 [30]	1/26	0/28	NR	NR	2/26	1/28
Luján, 2004 [31]	NR	NR	0/53	3/51	1/53	0/51
Smith, 2004 [32]	NR	NR	1/328	8/451	NR	NR
Sundbom and Gustavsson, 2004 [33]	8/25	5/25	NR	NR	0/25	0/25
Hutter, 2006 [34]	13/401	47/955	5/401	22/955	0/401	0/955
Campos, 2007 [35]	NR	NR	2/332	3/72	0/332	1/72
Nguyen, 2007 [36]	115/16,357	133/6,065	98/16,357	73/6,065	16/16,357	18/6,065
Agaba, 2008 [37]	NR	NR	3/806	1/561	0/806	2/561
Benotti, 2009 [38]	7/415	24/446	NR	NR	0/415	0/446
Kim, 2009 [39]	11/348	12/314	NR	NR	2/348	6/314
Barbalho-Moulim, 2011 [40]	NR	NR	0/13	0/13	NR	NR
de Wit, 1999 [41]	2/25	2/25	NR	NR	0/25	0/25
Skroubis, 2011 [42]	1/137	2/90	NR	NR	0/137	0/90
Banka, 2012 [43]	1,957/115,117	1,520/41,094	576/115,117	452/41,094	NR	NR

NR = Not reported; lap = laparoscopic.

design by several reports carry inevitable bias of indeterminable weight.

The pooled outcome estimates of the present analysis were in favor of the laparoscopic approach for the outcome measures pulmonary complications, pneumonia and mortality; however, careful consideration of internal and external sources of bias must be taken into account. The pooled weight of three population-based databases accounted for 68.5–98.3% of treatment effect, depending on the investigated outcome. Exclusion of these studies from the meta-analysis resulted in the reduction of ORs for all outcome parameters, although outcomes were constantly in favor of laparoscopy. Furthermore, due to the low incidence of pulmonary complications and the poor reporting of individual studies, no conclusions with regard to a potential association between pulmonary morbidity and mortality can be drawn.

The main methodological shortcoming of the present analysis is its limited external validity. Although the treatment effects apply to laparoscopic surgery of the upper abdomen, several factors have to be considered before being able to interpret the results. Several bariatric operations include manipulations in the upper and the lower abdomen, which requires transition from reverse Trendelenburg position to the supine position, and may result in changes in cardiac output and pulmonary circulation, especially in obese patients [44–47]. Furthermore, different procedures carry various risks of pulmonary complications [48]. Additionally, longer duration of surgery may result in increased pulmonary morbidity [49]; this factor could not however be taken into account in this analysis.

An apparent strength of the study is the adequate number of included reports, the large patient population and the extensive period of treatment, from the first decade of laparoscopic surgery for obesity up to present data. The likelihood of publication bias was low for the condition-specific outcome of pneumonia. The treatment effect of the laparoscopic and the open approach has resulted in distinct clinical outcomes and this was reflected in large treatment effects.

It is reasonable to argue that laparoscopy may be advantageous to open surgery in obese patients, although the available body of evidence derives mainly from observational studies, which appraised bariatric operations. The comparative clinical effect of laparoscopic surgery on pulmonary morbidity in obese patients remains a field of future investigation. More importantly, researchers are urged to provide detailed information on pulmonary

complications in their reports. Because obese patients account for a limited proportion of study populations, high-quality studies may include subgroup analyses or provide separate demographic and outcome data on obese patients. This approach allows for systematic and pooled analysis of homogeneous data in order to arrive at a valid clinical conclusion.

The comparative effect of laparoscopic and open surgeries on pulmonary complications of obese patients remains unclear. The available data have their origin from studies on bariatric surgery. Current evidence suggests lower pulmonary morbidity for laparoscopic surgery.

Disclosure Statement

The authors have no conflicts of interests related to this work to disclose.

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