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RESEARCH ARTICLE

Preoperative Cardiac and Pulmonary Assessment in Bariatric Surgery

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Abstract
Background Morbidly obese patients have a high prevalence of known and unknown cardiopulmonary diseases. The aim of this study was to assess the value of cardiopulmonary tests routinely performed before bariatric surgery.
Methods The population studied included 67 women and 10 men, aged 39±10 years, with a body mass index of 43±4 kg/m^2. All patients, candidates for laparoscopic gastric banding, underwent after clinical evaluation: resting electrocardiography (ECG), Doppler-echocardiography, exercise stress testing, Epworth Sleepness Scale, and polysomnography, spirometry, blood gases, and chest x-ray.
Results The ECG demonstrated conduction or ST-T wave abnormalities in 48 patients (62%). Prolongation of the QT interval>10% was found in 13 patients (17%). Stress tests were negative in 56 patients (73%) and were not interpretable in the remaining 21 patients (27%). Doppler-echocardiography showed hypertrophy of the left ventricular posterior wall in 47 patients (61%) without any consequences on perioperative management. Polysomnography showed an obstructive sleep apnea–hypopnea syndrome (OSAHS) in 31 patients (40%), leading to preoperative continuous positive airway pressure (CPAP) treatment in 17 patients (22%). Nevertheless, the Epworth Sleepness Scale was pathological in only 17 patients (22%). Ten patients (13%) presented minor chest x-ray alterations. Spirometry demonstrated an obstructive respiratory syndrome in 13 patients (17%) and a restrictive syndrome in five patients (6%). Hypoxemia <80 mmHg was observed in 21 patients (27%) and hypercapnia >45 mmHg in six patients (8%), without any consequences on the management of the perioperative period.
Conclusion We recommend the preoperative assessment by clinical evaluation, ECG, and polysomnography. For patients with cardiac or pulmonary histories and/or ECG abnormalities, we recommend echocardiography, spirometry, and blood gases.

Keywords Morbid obesity · Bariatric surgery · Anesthesia · Obstructive sleep apnea · Respiratory function · Polysomnography · ECG abnormalities

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Introduction

Before referring morbidly obese patients for bariatric surgery, the health care team should evaluate the benefit/risk ratio [1, 2]. The demonstrated advantages of reduced morbidity and mortality caused by weight loss [3–6] must be weighed against the risks of perioperative cardio-respiratory complications as respiratory failure, cardiac failure, coronary heart disease, arrhythmia [7–10]. Morbidly obese patients have increased morbidity and mortality [11] related to a high prevalence of cardio-respiratory diseases, which may be known or unknown at the time of surgery. They include obstructive sleep apnea–hypopnea syndrome (OSAHS) [12–14], restrictive pulmonary syndrome, cardiac failure, coronary heart disease, and prolongation of the QT interval [15–17]. The present study aimed to assess the prevalence of these associated morbidities, and the value of cardiopulmonary investigations routinely performed in a single cohort of patients, candidates for bariatric surgery.

Patients and Methods

Patients

The present study included 77 patients referred to our department of bariatric surgery between January and May 2006. The patients were aged 39±10 years (range 21–59), and 87% were female (Table 1). The mean body mass index (BMI) was 43±4 kg/m^2 and comorbidity with arterial hypertension (controlled by treatment with blood pressure <140/90 mmHg) was observed in 18 patients (23%). None of the patients had history of cardiac failure, coronary disease, or pulmonary disease. Seventeen patients (22%) were active smokers. Diabetes was known in 10 patients (13%), dyslipidemia with low-density lipoprotein (LDL) cholesterol levels over 3.4 mM in 33 patients (43%), triglyceride values of over 1.47 g/L in 23 patients (30%), and high-density lipoprotein (HDL) cholesterol values less than 1 mM in six patients (8%) (Table 1). None had hormonal dysfunction or kidney failure. Fifty-nine patients (77%) took regular treatment as antihypertensive treatment (*n*=18), antidepressive drugs (*n*=17), pain killers (*n*=12), antidiabetic treatment (*n*=10), and treatment against dyslipidemia (*n*=13).

Methods

All patients had a resting electrocardiogram (ECG), Doppler-echocardiography, an exercise stress test, a sleep-wake study with an Epworth Sleepness Scale and polysomnography, a spirometry and blood gases, and chest radiography. Investigations were performed during the preoperative period. For each patient and each investigation, the consequences of the results on preoperative, perioperative, and postoperative managements were specified. During the pre- and postoperative period (within 30 days after surgery), major cardiopulmonary events and mortality were precise.

Cardiological Investigations

An independent cardiologist analyzed the 12-lead ECG recordings at a speed of 25 mm/sec. The ECG abnormalities were defined as follows: short PR<120 ms, tachycardia >100 beats/min, bundle branch block, ST-T wave abnormalities, and arrhythmias. The corrected QT interval for heart rate (QTc), was calculated from Bazett's equation: $QTc=QT/\sqrt{RR}$, and was used to calculate the QTc/QT ratio, which was considered to be abnormal when >1.1.

The aim of the submaximal treadmill stress test was to detect latent coronary artery disease. The patient walked on an uphill treadmill in a graded exercise, under ECG and blood pressure monitoring. Every 3 min, the speed and the slope of the treadmill were increased. Intolerance signs were detected: hypertensive reactions with systolic blood pressure >250 mmHg or diastolic blood pressure >115 mmHg, precordial pain, ventricular arrhythmia, a ST-segment depression, or a severe fatigue. The stress test was considered as positive when it showed a ST-segment

Table 1 General characteristics of the population (*n*=77 patients)

Clinical data		Biochemical data	
Mean age (years)	39±10	Mean blood glucose (mM) (NV: 4.4–6)	5.8±1.6
Gender M/F	10/67	Mean HbA1c (%) (NV: 4–5.5)	5.8±0.6
Mean weight (kg)	115±16	Mean cholesterol (mM) (NV<3.4)	5.2±1
Mean height (cm)	162±0.1	Mean HDL-cholesterol (mM) (NV>1)	1.37±0.3
Mean BMI (kg/m^2)	43±4	Mean LDL-cholesterol (mM) (NV<1.3)	1.30±0.3
Mean SBP (mmHg)	123±19	Mean triglycerides (g/L) (NV<1.47)	1.41±0.7
Mean DBP (mmHg)	72±12		
Hypertension	18 patients (23%)		
Type 2 diabetes	10 patients (13%)		

NV=Normal Value, BMI=Body Mass Index, SBP=Systolic Blood Pression, DBP=Diastolic Blood Pression, HDL=High-Density Lipoprotein; LDL=Low-Density Lipoprotein.

depression of >0.1 mV starting >80 ms after the J-point (between the end of the ventricular depolarization QRS complex and the beginning of the ST-segment), presented in at least three consecutive heartbeats, the depression being horizontal (right away maximal) or down sloping (progressive). The stress test was interpretable only if the patient reached 85% of the theoretical maximal heart rate (MHR=220 beats/min minus age in years). Below this 85% of the theoretical MHR, the test was considered as uninterpretable.

Left ventricular function was assessed by two-dimensional and M-mode Doppler transthoracic echocardiography. Normal values were: left ventricular end-diastolic diameter (LVEDD) less than 55 mm or an indexed LVEDD (corrected for the body surface area) less than 32 mm/m^2; a left ventricular end-systolic diameter (LVESD) less than 40 mm; a left ventricular fractional shortening (LVFS) of over 30%; a posterior wall thickness (PWT) less than 10 mm; and an interventricular septal wall thickness (SWT) less than 12 mm. Two additional criteria of ventricular function were assessed: the left ventricular ejection fraction (LVEF) (measured by the Simpson's method), normally over 55%; and a left ventricular mass index (LVMi), normally less than 110 g/m^2. The LVMi was calculated from Devereux's formula according to the Penn convention ($LVMi=1.04[(SWT/10+LVEDD/10+PWT/10)^3-(LVEDD/10)^3]-13.8$ g) [18].

Sleep/Wake Investigations

The Epworth Sleepness scale is an 8-item questionnaire, widely used in pneumologist practice, presented to the patient [19]; it scores between 0 (least sleepy) and 24 (most sleepy), and indicates excessive daytime sleepness when ≥10.

Polysomnography was performed in all patients between 9 P.M. and 7 A.M., for detecting sleep-disordered breathing, especially OSAHS. Apnea and hypopnea were defined by airflow reductions, complete for apnea and 50% reduction for hypopnea, for at least 10 sec and were computed as an apnea–hypopnea index (AHI) or the number of apneas and/or hypopnea per hour. An AHI of more than 10 was considered diagnostic of an OSAHS. When the score was over 15, the patients were prescribed a 6-week preoperative course of CPAP treatment and hospitalization in intensive care for one night after surgery.

Pulmonary Investigations

After chest x-ray, spirometry and blood gases were performed according to standard criteria [20], on a computer-linked pneumotachograph. Total lung capacity (TLC), pulmonary flows, including the forced expiratory volume in 1 sec (FEV1), and forced vital capacity (FVC) were measured and the FEV1/FVC ratio calculated. An obstructive syndrome was defined as FEV1/FVC ratio less than 80% and a restrictive syndrome as TLC less than 80% of predicted value.

Cost of Investigations

The cost of each investigation was the price officially refunded to the patient by the French national health care system (Sécurité Sociale) in 2006 (http://www.ameli.fr).

Statistical Analysis

Statistical analysis was performed with SPSS (Inc., Chicago, IL, USA) using simple regression and correlation tests when appropriate. The results are presented as mean±SD.

No power analysis was done because there was no information in the literature indicating the frequency of this abnormalities in the morbidly obese patient and a proved link between correcting such abnormalities and avoiding postoperative complications.

Results

Cardiac Investigations

After clinical examination, we increased the antihypertensive treatment of five patients before surgery.

All ECG abnormalities were referred to a specialist cardiological opinion and none was considered to be a contraindication to bariatric surgery. Nevertheless, we avoided medications that prolong the QT interval in patients with long QT (Table 2).

In 48 patients (62%), ECG had abnormalities such as left ventricular hypertrophy (n=2), right ventricular hypertrophy (n=6), short PR interval (n=9), bundle branch block (n=11), ST-T wave abnormalities (n=18), atrioventricular block (n=2), microvoltage (n=4), tachycardia (n=4), atrial or ventricular ectopic beats (n=4). Thirteen patients (17%) had over 10% prolongation of QT interval (Table 2).

None of the patients had a positive stress test. The investigation was uninterpretable in 21 patients (27%) because 85% of the theoretical MHR was not attained in these patients. Five patients have had limited interpretation of their stress test because they had drugs that determined bradycardia (beta-blockers), seven patients because they had gonarthrosis, and nine presented early severe fatigue during the stress test. This test had no consequences on preoperative and perioperative managements.

Doppler-echocardiography showed hypertrophy of the posterior wall in 47 patients (61%) and of the septum in 19

Table 2 Cardiac investigations (n=77 patients)

Investigations	Mean results	Normal results	Abnormal results
Electrocardiogram			
QTc/QT (NV<1.1)	367±33/356±32	64/77 (83%)	13/77 (17%)
Conduction and/or repolarization abnormalities (NV=0)		29/77 (38%)	48/77 (62%)
Stress test			
MHR (NV> 5%)	88±7	56/77 (73%)	21/77 (27%)
Horizontal or down sloping depression of at least 1 mm (NV=0)		77/77 (100%)	0/77 (0%)
SBP (mmHg) (NV<250)	205±29	71/77 (92%)	6/77 (8%)
DBP (mmHg) (NV<100)	88±12	76/77 (99%)	1/77 (1%)
Echocardiography			
LVEDD (mm) (NV<55)	49±4	69/77 (90%)	8/77 (10%)
LVEDDi (mm/m^2) (NV<32)	22±2.2	77/77 (100%)	0/77 (0%)
LVESD (mm) (NV<40)	31±3	77/77 (100%)	0/77 (0%)
SWT (mm) (NV<12)	10.6±1.7	58/77 (75%)	19/77 (25%)
PWT (mm) (NV<10)	9.8±1.45	30/77 (39%)	47/77 (61%)
LVFS (NV>30%)	37±5	72/77 (94%)	5/77 (6%)
LVEF (NV>55%)	67±6	76/77 (99%)	1/77 (1%)
LVMi (g/m^2) (NV<110)	97±22	61/77 (79%)	16/77 (21%)

NV=Normal Value, QT=interval for heart rate, QTc=corrected QT interval, MHR=Maximal Heart Rate, SBP=Systolic Blood Pression, DBP=Diastolic Blood Pression, LVEDD=Left Ventricular End Diastolic Diameter, LVEDDi=LVEDD corrected for the body surface, LVESD = Left Ventricular End Systolic Diameter, SWT=Septum Wall Thickness, PWT=Posterior Wall Thickness, LVFS=Left Ventricular Fractional Shortening, LVEF=Left Ventricular Ejection Fraction, LVMi=Left Ventricular Mass Index.

patients (25%) (Table 2). This finding had no consequences on preoperative and perioperative managements.

Sleep/Wake Investigations

OSAHS with an AHI >10 were detected in 31 patients (40%), including 17 patients (22%) with AHI superior to 15 (Table 3). These patients were managed with a 6-week period of CPAP treatment before surgery and hospitalization in intensive care for one night after surgery.

Fourteen patients with documented OSAHS had a normal Epworth Sleepness Scale, including five patients with AHI>15; they were all prescribed CPAP treatment for a 6-week period before surgery and hospitalization in intensive care for one night after surgery. Epworth Sleepness Scale was falsely negative in 14 patients, i.e., 45% of the patients with OSAHS. Nevertheless, whenever the Epworth Sleepiness Scale was positive, OSAHS was observed by polysomnography.

Pulmonary Investigations

Ten patients (13%) had chest x-ray changes: of these, six showed increased cardiothoracic index, three a bilateral interstitial pattern, and one an elevated diaphragm (Table 4) without any consequences on perioperative management.

Spirometry demonstrated the presence of an obstructive syndrome (FEV1/FVC<80%) in 13 patients (17%) and of a restrictive syndrome (TLC<80%) in five patients (6%). Hypoxemia <80 mmHg was observed in 21 patients (27%) and hypercapnia >45 mmHg in six patients (8%). The results of these chest x-rays, spirometry, and blood gases did not have any consequences on preoperative and perioperative managements (Table 4).

Table 3 Sleep/wake investigations (n=77 patients)

Investigations	Means results	Normal results	Abnormal results
Epworth Sleepness Scale (NV<10)	7.5±5	60/77 (78%)	17/77 (22%)
Polysomnography			
AHI (NV<10 apneas or Hypopnea per hour)	18±22	46/77 (60%)	31/77 (40%)
Basal O_2 saturation (NV>95%)	96±3	62/77 (81%)	15/77 (19%)
Low O_2 saturation (NV>90%)	82+10	23/77 (30%)	54/77 (70%)
Snoring (NV=0)		5/77 (6%)	72/77 (94%)

NV=Normal Value, AHI=Apnea–Hypopnea Index.

Table 4 Pulmonary investigations (n=77 patients)

Investigations	Means results	Normal results	Abnormal results
Chest x-ray		67/77 (87%)	10/77 (13%)
Spirometry			
TLC (NV>80%)	99±13	72/77 (94%)	5/77 (6%)
FEV1/FVC (NV>80%)	87±7	64/77 (83%)	13/77 (17%)
Blood gases			
Arterial pO_2 (mmHg) (NV>80)	88±13	56/77 (73%)	21/77 (27%)
Arterial pCO_2 (mmHg) (NV<45)	39±4	71/77 (92%)	6/77 (8%)

NV=Normal Value, TLC=Total Lung Capacity, FEV1=Forced Expiratory Volume in 1 sec, FVC=Forced Vital Capacity.

Cardiac and Pulmonary Events

No mortality and no major cardiopulmonary events as pulmonary failure, pneumonia, cardiac failure, coronary heart disease, arrhythmia, and pulmonary embolism were observed during the perioperative and postoperative periods.

Cost of Investigations

The total cost of ECG, Doppler-echocardiography, stress test, sleep-wake study with an Epworth Sleepness Scale and a polysomnography, spirometry, blood gases, and chest radiography was 436.04 euros per patient (Table 5).

Discussion

In the literature, there is no specific guideline for preoperative evaluation of morbidly obese candidates to bariatric surgery. No evaluation has determined the frequency of these abnormalities, nor established the profile of these patients at risk. We conducted our study to evaluate which exams are necessary in preoperative period to prevent such events. We detected ECG abnormalities and OSAHS in 62% and 40% of patients, respectively. None was a contraindication to bariatric surgery. No adverse cardiopulmonary event or mortality was observed in our patients. However, it must be pointed out that the patient group included mainly young patients (mean age 39 years) with 87% of women, and a specifically trained surgeon and anesthetist managed them. This recruitment is representative of French experience [21]. In this study, many investigations were noncontributory by their negative or non-informative results for risk evaluation for this type of surgery. The finding of OSAHS affected the preparation of our patients. This led to the prescription of preoperative CPAP and intensive care for one night in the postoperative period because the risk of coronary heart disease and heart failure is significantly increased in the perioperative and postoperative periods in patients with untreated OSAHS [22].

Table 5 Cost of investigations per patient (from the French national health care system in 2006 [http://www.ameli.fr])

Investigations	Cost (euros)
Electrocardiogram	23.50
Doppler-echocardiography	81.17
Exercise stress test	76.80
Epworth Sleepness Scale	0
Polysomnography	148.06
Chest x-ray	12.25
Spirometry	66.80
Blood gases	27.46
Total	436.04

Some of the abnormalities found in our population could be life threatening. The long QT syndrome is potentially arrhythmogenic, and may predispose to ventricular tachycardia with syncope, cardiac arrest, and sudden death, especially during anesthesia [17]. The treatment of reference for prolonged QT interval is beta-blocker only in its congenital forms, because it was evidenced that it improved prognosis. In other circumstances there is no recommendation. Nevertheless, the presence of long QT interval is a relative contraindication for some anesthetic medications as Desflurane [23]. Yildirim et al. [23] showed that this inhaled anesthetics prolong the QT interval in patients with long QT. In our current practice, we avoid medications that prolong the QT interval in patients with long QT.

There are two guidelines in the literature [24, 25] concerning cardiac and pulmonary risk evaluation before noncardiac surgery. They state that obesity and surgery duration are risk factors, but not powerful markers of increased risk for postoperative cardiac or pulmonary complications. Recently, in an observational study, Klasen et al. [10] did not observe increased mortality in patients with a mean BMI of 34.4 kg/m^2. Postoperative pulmonary complications rates were 6.3% and 7% for obese and non-obese patients, respectively, in studies that reported only univariate data [25]. Only patients with previous myocardial infarction, angina, heart failure, diabetes, or renal insufficiency have a higher cardiac risk according to ACC/AHA guidelines [25]. However, no increase in mortality was observed in 52 patients with clinical coronary artery disease, compared with 507 control subjects undergoing gastrointestinal bypass surgery [26]. They concluded that chest radiography, spirometry, or stress test was not needed in the absence of clinical predictor elements. On the other hand, increased mortality has been reported in bariatric surgery, and obesity appears to be an independent risk factor of morbidity and mortality [1–11, 27] from cardiovascular and pulmonary complications. Flum et al. [9] showed that the risk of early death after bariatric surgery was closely associated with advanced age, male sex, and inexperienced surgeon. The absolute perioperative mortality rate (4.8% within 30 days) in patients aged 65 years or older undergoing bariatric procedures is more than twice the risk of mortality associated with coronary revascularization (2%) or hip replacement (1%) [9]. Recently, Hamoui et al. indicated that the risk of non-surgical complications such as chest infection and renal failure was significantly associated with the reduction of the forced vital capacity (FVC), the forced expiratory volume in 1 sec (FEV1), and total lung capacity (TLC) [28].

Obstructive and restrictive pulmonary syndromes, silent coronary heart diseases, or subclinical heart failure could decompensate in the immediate postoperative period. Fortunately, in anesthesiology, the use of new drugs, better monitoring procedures, and ventilators able to detect and cure these disorders have improved the prognosis. The greater level of surveillance of these patients probably explains the low incidence of fatal events [10]. Nevertheless, in our present experience we would underline the need to look for and treat OSAHS in these patients. Although there is no controlled trial to support this recommendation, reports in the literature emphasize the importance of this risk. The OSAHS is a condition characterized by the presence of repetitive upper airway obstruction during sleep. The mechanism remains uncertain, but OSAHS sufferers have functionally impaired upper airway muscles, causing a reduction in tonic and phasic contraction during sleep [29]. Commonly, the reduced contractions cause partial (hypopnea) or complete (apnea) occlusion of airflow, resulting in oxygen desaturation and sleep fragmentation. Only polysomnography and not the Epworth Sleepness Scale, in our experience, was reliable to diagnose this syndrome, suggesting that a normal Epworth Sleepness Scale should not be used alone for diagnosis of the OSAHS. In our experience, 40% had AHI>10 and 22% >15 indicating therapy. Many data have demonstrated that OSAHS can be improved by CPAP, and nontreated syndromes could be aggravated by anesthesia causing lethal apnea [24]. No perioperative complications were observed after systematic preoperative CPAP preparation (6 weeks). Other teams do not use this guideline, but we must point out that even if CPAP benefit is not observed in the perioperative period, it significantly improved the quality of life and dyspnea of these patients [27].

Our results suggest that preoperative cardiopulmonary evaluations could be divided in three groups. The first is the noninformative group because the results were negative and/or had no value for management: stress test, Epworth Sleepness Scale. The second is the informative group because results were often abnormal but with no consequences on surgery decision and with few consequences on management: chest x-ray, Doppler-echocardiography, spirometry, blood gases. The third is the informative and pertinent group to avoid complications: polysomnography, ECG.

The total cost of investigations was 436.04 (Table 5). If we had limited the investigation to ECG and polysomnography, the savings would have been 171.56 euros per patient.

The preoperative assessment by clinical evaluation, ECG, and polysomnography is essential. We recommend the systematic detection of OSAHS by polysomnography to avoid the possible risk of coronary heart disease and heart failure in the perioperative period. We recommend the systematic ECG for the detection of ECG abnormalities. In view of the nondecisive results of Epworth scores and stress tests, we do not recommend these investigations. We strongly recommend echocardiography, spirometry and blood gases in patients with cardiac or pulmonary histories or ECG abnormalities.

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