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Impact of lung volume reduction surgery *versus* rehabilitation on quality of life

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Impact of lung volume reduction surgery versus rehabilitation on quality of life. T.C. Mineo, V. Ambrogi, E. Pompeo, S. Elia, D. Mineo, P. Bollero, I. Nofroni. ©ERS Journals Ltd 2004.

ABSTRACT: This study aims at evaluating the effects of lung volume reduction *versus* respiratory rehabilitation on quality of life, assessed by three different questionnaires.

Sixty emphysematous patients were randomised by computer to receive either surgery (n=30) or rehabilitation (n=30). Life quality was evaluated by the Nottingham Health Profile, the Short Form (SF)-36 item and the St George′s questionnaires.

As reported previously, dyspnoea index, forced expiratory volume in one second, residual volume, 6-min walk test and arterial oxygen tension improved after surgery more than after rehabilitation. Quality of life was significantly improved after surgery as follows Nottingham Health Profile physical mobility; SF-36 physical and social functioning, mental and general health, emotional role; St George′s general, activity.

At multivariate analysis 6- and 12-month changes after surgery of Short Form-36 physical functioning, general health, and St George′s activity domains were significantly correlated with forced expiratory volume in one second, while Short Form-36 social functioning and Nottingham Health Profile isolation correlated with residual volume. Functional and especially symptomatic improvements persisted: dyspnoea index, residual volume, and Short Form-36 and St Georges′s physical scores were still significant at 4 yrs. Surgery produces greater and longer effects than rehabilitation on quality of life by improving both physical and psychosocial domains. Symptomatic improvements persisted at 4 yrs.

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Both lung volume reduction and respiratory rehabilitation improve exercise tolerance and dyspnoea in patients with severe emphysema [1, 2]. Furthermore, many papers claimed the role of surgery [3–9] or respiratory rehabilitation [10] in improving quality of life, which is considered a primary outcome.

Surprisingly, the improvement in quality-of-life domains following surgery [1, 5, 6] usually exceeds that achieved in functional parameters. This finding suggests that the underlying mechanisms of quality-of-life improvement are not yet fully elucidated. Moreover, the difficult evaluation of such a subjective matter hinders a reliable comparison among different series.

It was hypothesised that the different improvement between quality-of-life and respiratory function parameters could be due to an additional dependent/independent role played by psychosocial function domains. This further study more specifically evaluates the impact of surgery *versus* rehabilitation on quality of life in the same series of patients [7] by means of three widespread and validated questionnaires.

Materials and methods

The trial was designed as a randomised, two-armed study with a sole lung volume reduction group *versus* a sole respiratory rehabilitation group as controls (fig. 1), approved by the University Ethical Committee. Results were evaluated through intragroup and intergroup analyses. Trial size was statistically established as referred in a previous report [7].

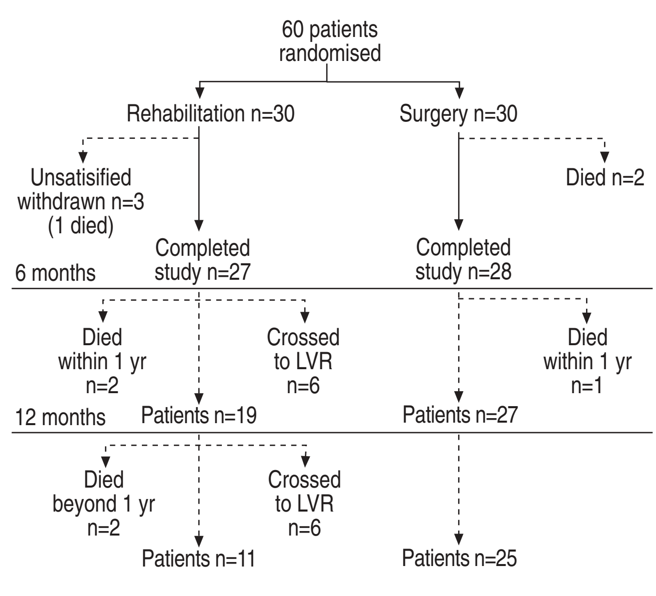

Fig. 1. – Algorhythm showing randomisation and outcome of the patients randomised. LVR: lung volume reduction.

The limit for allowing crossover between treatment arms was set at 6 months, namely the period of maximal expected improvement for either treatment.

The study started in January 1996 and was closed in January 1999. Written informed consent was obtained from all patients. No patient had giant bullae, clinically dominant bronchitis or bronchiectasis, asthma or systolic pulmonary artery pressure of >55 mmHg.

Sixty patients were randomised by computer into two groups: 30 patients underwent video-assisted thoracoscopic lung volume reduction and 30 patients underwent a comprehensive rehabilitation programme, for a minimum of 6 weeks.

Quality of life was assessed by means of three self-administered questionnaires: 1) Nottingham Health Profile (NHP) [11, 12], which contains 38 dichotomic-choice questions relating to eight domains, mobility, energy, pain, social isolation, sleep disturbance, and emotional reactions (best score=0, worst=100); 2) Medical Outcomes Study Short Form (SF)-36 item [13, 14], which consists of 36 multiple-choice questions that cover eight health concepts, physical functioning, social functioning, physical role, emotional role, vitality, bodily pain, mental health, and general health perception (best score=100, worst=0). To simplify the evaluation, physical component summary and the SF-36 general score derived from the formula ((all answer score–lowest score possible/highest score possible)×100) were also used; and 3) St George's Respiratory Questionnaire (SGRQ) [15, 16], which is specifically targeted to quantify the impact of diseases of chronic airflow limitation on health and well-being. It contains 76 items organised into three sections investigating symptom, activity and impact of these limitations on mood state (best score=0, worst=100).

These questionnaires were chosen due to their relative simplicity, wide use in chronic pulmonary diseases, and availability into validated version for the Italian population [12, 14, 16]. Questionnaires were administered just before randomisation, at 6 months and then once per year. Results of randomisation were kept blind to questionnaires examiners. Furthermore, patient's satisfaction with the operation was assessed by asking to choose one of the five possible responses: *scarso* (poor), *discreto* (fair), *buono* (good), *molto buono* (very good), *ottimo* (excellent).

Physiological assessment included measurement of body mass index, arterial blood gases, plethysmography, timed spirometry, diffusing capacity for carbon monoxide of the lung and perfusion scan. Digital chest radiographs, high-resolution and volumetric helical computed tomography (CT) of the chest were performed in all patients for analysis of emphysema morphology and volumes. Exercise tolerance was assessed by a standard 6-min walk test, which was performed in a 50-m long corridor, following a modification of the protocol described by GUYATT *et al.* [17]. Patients were instructed and trained to walk from end-to-end of the corridor and to cover as much distance as possible in the allotted period of 6 min. Encouragement was routinely carried out during the test by a supervisor. Patients were allowed to stop and rest during the test, but to resume walking as soon as they felt able to do so. At the beginning and then at 2-min increments, the dyspnoea was rated using a modified Borg scale. Oxygen saturation was monitored with a pulse oxymeter, and if necessary supplemental oxygen was provided by nasal prongs to maintain an arterial oxygen saturation of >90%.

At baseline and during the follow-up visits, dyspnoea was rated according to the modified Medical Research Council Score. Complete symptomatic and functional assessment was repeated 6 months after completion of treatment and then every year.

Patients assigned to surgical arm underwent tailored unilateral or bilateral operation. Unilateral surgery was performed in patients older than 70 years with associated comorbidity, an asymmetric distribution of the emphysema between the lungs identified at high-resolution CT and/or perfusion scan. All other patients with symmetric and heterogeneous emphysema underwent bilateral surgery. Surgical technique has been extensively described elsewhere [7]. Briefly, the operation was aimed at reducing 30% of the lung volume by staple excision of severely hyperinflated emphysematous lung tissue by means of thoracoscopic approach.

The rehabilitation programme was directed to optimise the ability to perform daily-living activities by improving exercise capacity. It entailed 3-h supervised sessions over 5 days per week for 6 weeks. The first half of each session included educational activity such as breathing retraining, chest clearance, energy conservation, nutritional and medication education, and psychosocial support. The second half of each session began with a 30-min class that included stretching and rotation of major joints and muscles while promoting diaphragmatic and pursed-lip breathing. Subsequent exercise activities included inspiratory resistive exercises, interval training, treadmill, upper and lower extremities' training.

During interval training, exercises of low and high power were performed on an individual basis for 40 min. Treadmill was performed with an initial 3–5-min exercise up to 20 min with a stepwise increase of both speed and gradient according to a modified Bruce protocol. Upper extremity endurance training included stretching and light weight-training exercises repeated 10–15 times at each session. Walking at a leisurely pace for up to 30 min was carried out at least twice per week. The time-frame of the rehabilitation was 6.36±0.9 weeks (mean±SD).

Oxygen dependency was considered whenever arterial oxygen tension (P_{a,O_2}) was $\leqslant$8.64 kPa. Steroid dependency was defined by an oral methylprednisolone intake of $\geqslant$8 mg·day^{-1} for $\geqslant$1 month within the last year's pretreatment.

Nonparametric tests were prudentially used since the distribution of some variables was not normal at the normality test. The Wilcoxon or the Mann-Whitney tests were used for paired and unpaired data, respectively.

Stepwise logistic regression multivariate models analysed the dependence of significantly improved functional parameters (independent variable) and life quality domains (dependent variable) in the surgical group. Those values greater than the median of the positive changes of each domain were chosen as outcome cut-offs.

Results

At study entry, no difference was found between the rehabilitation and surgical arms in demographics, pulmonary function, ergometric tests, dyspnoea index, basal life quality scores, drug treatment, and oxygen requirements (table 1).

Seventeen patients underwent bilateral and 13 unilateral lung volume reduction. There was no difference between the surgical and rehabilitation arm in 6-month mortality (two *versus* one patient, NS) and late (>30 days) morbidity (three *versus* four patients, NS), however, as expected, early morbidity [7] was higher in the surgical arm (16 patients *versus* none, $p<0.00001$).

Within the first post-treatment year, one patient died at 8 months in the surgical arm, and two patients died at 7 and 10 months in the rehabilitation arm. In the same period, six patients crossed over from the rehabilitation arm to surgical treatment due to unsatisfactory improvements (fig. 1). Intergroup comparison showed that a greater number of patients had complications (fatal plus nonfatal) within the 6 months

Table 1. – Respiratory function indexes pre- and post-treatment and intra/intergroup significance

Respiratory function indexes	Surgery			Rehabilitation			Intergroup changes
	Baseline	6 months	12 months	Baseline	6 months	12 months	6 months
Subjects n	30	28	27	30	27	19	
Dyspnoea MRC	3.3±0.1	1.7±0.1***	1.9±0.1***	3.3±0.1	2.9±0.1*	3.0±0.1	<0.0001
FEV1							
L	0.8±0.06	1.3±0.1***	1.2±0.07***	0.8±0.03	0.8±0.04	0.8±0.03	<0.0001
% pred	30.2±1.9	44.3±2.9	41.2±2.6	31.4±2.7	31.2±2.5	30.9±2.8	
FVC							
L	2.5±0.1	2.9±0.1**	2.7±0.1*	2.5±0.06	2.5±0.06	2.4±0.06	<0.0001
% pred	66.6±2.9	80.3±3.0	76.9±2.9	65.2±2.9	65.2±2.8	64.2±2.8	
RV plethysmography							
L	5.5±0.1	4.1±0.1***	4.2±0.1***	5.1±0.1	5.1±0.1	5.1±0.1	<0.0001
% pred	240.1±5.9	182.2±5.3	184.3±5.6	237.2±5.5	238.1±5.5	239.2±5.1	
$D_{L,CO}$ mmol·kPa^{-1}·min^{-1}	2.7±0.1	2.7±0.1	2.7±0.1	2.8±0.1	2.7±0.1	2.7±0.1	<0.01
P_{a,O_2} kPa	9.0±0.1	9.7±0.1***	9.5±0.1**	8.5±0.1	8.3±0.1*	8.5±0.1	<0.002
P_{a,CO_2} kPa	5.3±0.1	5.2±0.1	5.2±0.1	5.3±0.1	5.3±0.1	5.4±0.1	NS
MIP mmHg#	50.0±2.4	70.0±2.7***	65.4±2.7***	54.0±2.9	64±2.2**	61.2±2.7**	NS
MEP mmHg¶	77.0±2.1	82.0±3.9	82±3.1	81.0±2.7	83±3.2	83±2.7	NS
Body weight kg	65.0±1.9	68.4±1.8**	69.3±1.9**	66.9±1.5	65.8±1.3	66.0±1.5	<0.0001
6-min walk m	380±7.8	473±13***	458±10.2***	376±7.3	408±8.4***	383±7.6	<0.0002
O_2-dependent patients %	63.3	7.1***	14.8***	60.0	55.5	82.4	<0.02
Steroid users %	73.3	14.2***	22.2***	80.0	55.5*	82.4	NS

Data are presented as mean±SEM unless otherwise stated. MRC: Medical Research Council; FEV1: forced expiratory volume in one second; % pred: % predicted; FVC: forced vital capacity; RV: residual volume; $D_{L,CO}$: diffusing capacity of carbon monoxide for the lung; P_{a,O_2}: arterial oxygen tension; P_{a,CO_2}: arterial carbon dioxide tension; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; NS: nonsignificant. #: at residual volume; ¶: at total lung capacity. *: p<0.05; **: p<0.01; ***: p<0.001.

after rehabilitation than after surgery (nine *versus* three patients, p=0.03). At 6, 12, 24, 36 and 48 months, 95, 90, 84, 80 and 75% of the operated patients expressed good-to-excellent satisfaction, respectively.

Functional changes in the two groups are described in table 1. The surgical group presented a significant improvement in dyspnoea index, forced expiratory volume in one second (FEV1), residual volume (RV), P_{a,O_2}, and 6-min walk test at both 6 and 12 months. Indexes of quality of life, tested after 6 and 12 months, are described in table 2. A significant intragroup improvement after surgery was found in the NHP general score (p=0.02), and in mobility (p=0.005), pain (p=0.001), and social isolation (p=0.002) domains. The same analysis performed by the SF-36 questionnaire showed a significant improvement in general score (p=0.0001) and all specific domains, except physical role and vitality. As far as the

Table 2. – Quality of life after lung volume reduction or respiratory rehabilitation

Quality-of-life domains	Surgery			Rehabilitation			Intergroup changes
	Baseline	6 months	12 months	Baseline	6 months	12 months	6 months
Subjects n	30	28	27	30	27	19	
NHP	29.7±3.6	16.0±3.2**	17.2±2.3**	33.0±4.0	30.1±4.1	32.4±4.5	NS
Mobility	45.6±5.3	26.3±4.3**	28.3±4.4**	44.3±6.2	40.3±5.2	49.4±9.3	0.04
Energy	25.7±5.6	23.1±5.8	22.4±5.2	33.3±6.2	31.3±6.6	32.9±9.8	NS
Pain	32.2±4.2	11.8±3.4**	11.4±3.7***	31.6±5.3	25.4±3.1	26.3±6.1	NS
Sleep	39.6±6.8	22.2±6.4	24.9±6.7	35.2±6.4	35.4±6.9	31.0±6.1	NS
Social isolation	12.6±3.1	2.1±8.2**	2.3±1.6**	19.9±5.2	16.8±5.1	25.5±8.8	NS
Emotional reactions	18.0±3.8	11.7±4.6	12.6±4.5	24.8±5.5	24.7±5.4	26.6±9.5	NS
Short Form-36	51.1±2.2	67.4±2.0***	63.2±1.8**	49.1±2.9	51.3±3.0**	47.5±4.1	0.0001
Physical functioning	31.6±3.8	60.5±4.9***	53.2±4.4***	37.1±4.4	43.6±4.9*	37.3±7.3	0.001
Role physical	25.8±7.7	41.9±9.0	35.5±8.7	27.5±7.3	39.6±8.5	23.0±7.1	NS
Bodily pain	68.5±6.0	85.7±4.2**	88.1±4.3**	64.5±6.9	69.9±6.8	64.5±9.2	NS
General health	44.5±2.6	62.5±2.5***	60.2±2.7***	44.1±2.9	46.5±3.2	41.8±4.9	<0.0001
Vitality	58.0±3.1	62.1±2.7	60.7±2.9	50.1±2.8	51.8±2.6	43.8±4.0	NS
Social functioning	62.5±3.0	83.0±2.8***	78.8±2.9***	60.4±3.7	66.8±4.3*	55.7±4.6	0.004
Role emotional	41.1±7.0	82.1±6.0**	74.3±6.4**	48.8±7.7	61.9±7.5	43.5±10.9	0.02
Mental health	61.0±3.9	71.2±3.5**	70.1±3.7**	55.3±4.8	54.2±4.7	52.9±6.3	0.003
Physical component summary	34.1±1.0	42.0±1.6**	39.4±1.5**	34.8±1.5	37.6±1.3*	35.8±2.1	0.01
SGRQ	38.5±4.6	24.6±3.6***	29.0±3.5**	37.9±4.9	31.6±5.2*	36.8±4.9	0.0001
Symptoms	31.6±4.4	21.3±3.9**	22.8±3.4**	29.6±5.0	23.7±3.7*	24.0±5.2*	NS
Activity	47.5±5.0	27.3±3.2***	38.4±5.2***	41.9±4.8	36.2±26.6*	44.4±4.8	0.0001
Impact	18.8±2.5	12.2±3.9**	14.5±1.8**	20.2±2.7	16.8±13.6*	21.0±3.8	NS

Data are presented as mean±SEM unless otherwise stated. NHP: Nottingham Health Profile; SGRQ: St George's Respiratory Questionnaire; NS: nonsignificant. *: p<0.05; **: p<0.01; ***: p<0.001.

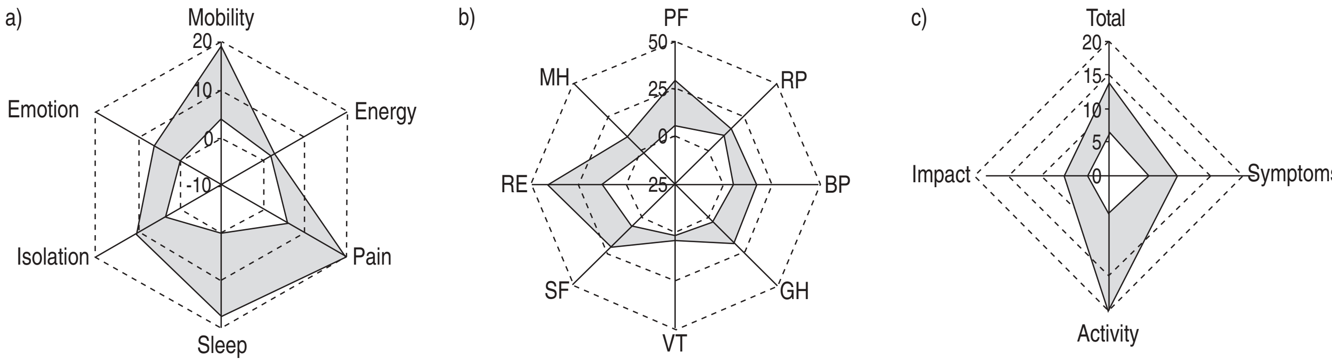

Fig. 2. – Mean changes at 6 months from randomisation of surgery (■) and rehabilitation (□) evaluated by the a) Nottingham Health Profile, b) Short Form-36 and c) St George's Respiratory Questionnaire. PF: physical functioning; RP: role physical; BP: bodily pain; GH: general health; VT: vitality; SF: social functioning; RE: role emotional; MH: mental health.

SGRQ is concerned, it was found that total score ($p<0.001$), symptoms ($p=0.01$), activity ($p<0.001$), and impact ($p<0.01$) domains were all significantly improved at 6 and 12 months. All life quality improvements were significantly greater at 6 months in the surgical group (fig. 2) and remained stable up to 1 yr (table 2).

None of the NHP domains improved significantly in the rehabilitation arm. In the same arm, SF-36 showed improvements in general score ($p=0.004$), and in physical ($p=0.04$) and social functioning ($p=0.01$) domains. In addition, significant improvement occurred in SGRQ total, symptoms, activity and impact at 6 months. The improvement in symptoms was still present at 12 months.

Intergroup 6-month post-treatment changes are detailed in table 2. By using the NHP, a better improvement in surgery *versus* rehabilitation was demonstrated only in physical mobility ($p=0.04$) whereas with the SF-36 questionnaire, general scores ($p=0.0001$) and five domains (physical functioning $p=0.001$, general health $p<0.0001$, social functioning $p=0.004$, emotional role $p=0.02$, mental health $p=0.003$) were improved. Finally, both SGRQ total score and activity domain showed a significant intergroup difference ($p=0.0001$) in favour of the surgery group. Intergroup changes were significant without the need of including deaths and withdrawals as the most negative score.

Significant dependences between quality-of-life domains and functional parameters at the stepwise logistic regression analysis are shown in table 3. Six-month changes of SF-36 physical functioning ($p=0.01$), general health ($p=0.04$) and physical component summary ($p=0.03$) correlated with changes in FEV_1; both SF-36 social functioning ($p=0.02$) and NHP social isolation domain ($p=0.04$) were correlated with RV decrement. Among the SGRQ domains, activity ($p=0.01$) was correlated with FEV_1 increment.

Results of the patients in the surgical arm for 2-, 3- and 4-yr periods are reported in table 4. At 4 yrs, the 24 patients of the surgical group still presented a significantly better dyspnoea index ($p=0.002$), SF-36 physical functioning ($p=0.0002$), SGRQ general ($p=0.03$), symptoms ($p=0.002$), and activity ($p=0.005$).

Interestingly, physical domain changes at 3 and 4 yrs postoperatively showed a significant interdependence only with reduction of RV (table 3).

Table 3. – Multivariate logistic regression model between the percentage change of lung function parameters and significant changes in quality-of-life domains in the surgical group

Quality-of-life questionnaires	6 months	12 months	24 months	36 months	48 months
Short Form-36					
Physical function					
Selected variable	FEV_1	FEV_1	FEV_1	RV	RV
p-value	0.01	0.01	0.04	0.01	0.01
General health					
Selected variable	FEV_1				
p-value	0.04	NS	NS	NS	NS
Social functioning					
Selected variable	RV	RV	RV		
p-value	0.02	0.02	0.02	NS	NS
Physical component summary					
Selected variable	FEV_1	FEV_1			
p-value	0.03	0.04		NS	NS
NHP					
Social isolation					
Selected variable	RV	RV			
p-value	0.04	0.05		NS	NS
SGRQ					
Activity					
Selected variable	FEV_1	FEV_1	FEV_1	RV	RV
p-value	0.01	0.03	0.04	0.04	0.04

NHP: Nottingham Health Profile; SGRQ: St George's Respiratory Questionnaire; FEV_1: forced expiratory volume in one second; RV: residual volume. NS: nonsignificant.

Table 4. – Long-term effect of lung volume reduction

Respiratory function indexes	2 yrs		3 yrs		4 yrs	
	Mean±SEM	p-value#	Mean±SEM	p-value#	Mean±SEM	p-value#
Subjects n	25		24		24	
Dyspnoea MRC	1.92±0.20	<0.0001	2.04±0.10	0.0001	2.46±0.10	0.002
FEV1 L	1.15±0.10	0.0001	1.03±0.10	0.01	0.91±0.10	NS
FVC L	2.72±0.10	0.001	2.66±0.10	0.01	2.56±0.10	NS
RV plethysmography L	4.57±0.10	<0.0001	4.73±0.10	<0.0001	4.92±0.10	0.0001
P_{a,O_2} kPa	9.8±0.1	NS	9.5±0.1	NS	9.3±0.1	0.04
P_{a,CO_2} kPa	5.3±0.1	NS	5.3±0.1	NS	5.4±0.1	NS
NHP	19.7±3.1	0.02	22.2±2.3	0.03	27.1±3.1	NS
Mobility	29.6±4.3	0.01	34.3±4.4	0.02	38.1±4.2	0.05
Social isolation	2.6±2.9	0.02	4.3±1.6	0.05	10.8±2.1	NS
Short Form-36	61.1±3.1	0.01	60.2±2.2	0.02	56.3±3.1	0.05
Physical functioning	53.1±2.1	<0.0001	49.2±1.9	<0.0001	44.6±2.0	0.0002
General health	51.5±2.6	0.01	49.2±2.7	0.05	44.5±3.2	NS
Social functioning	72.5±3.0	0.01	65.8±2.9	NS	59.8±4.3	NS
Physical component summary	38.1±1.0	0.01	37.4±1.5	0.05	37.3±1.3	0.05
SGRQ	30.5±3.6	0.01	31.0±3.5	0.03	31.6±5.2	0.03
Symptoms	23.6±3.4	0.002	23.8±3.4	0.002	23.7±3.7	0.002
Activity	38.5±5.0	0.002	38.4±5.2	0.002	39.2±26.6	0.005
Impact	14.8±2.5	0.01	15.5±1.8	0.02	16.8±13.6	0.05

MRC: Medical Research Council; FEV1: forced expiratory volume in one second; FVC: forced vital capacity; RV: residual volume; $D_{L,CO}$: diffusing capacity of carbon monoxide for the lung; P_{a,O_2}: arterial oxygen tension; P_{a,CO_2}: arterial carbon dioxide tension; NHP: Nottingham Health Profile; SGRQ: St George's Respiratory Questionnaire; #: p-value *versus* baseline.

Discussion

In the present cohort of patients the authors have already shown that sole lung volume reduction surgery is superior to respiratory rehabilitation in improving lung function, muscle strength, exercise capacity [7], and body weight especially in the fat-free mass [18]. In the present study improvement in quality-of-life domains, tested by three of the most used questionnaires, were found to last for a longer period of time after surgery than after respiratory rehabilitation. The greater impact of surgery over medical treatment in determining quality-of-life improvements has already been suggested by CRINER *et al.* [4] with the Sickness Impact Profile [19] and by GEDDES *et al.* [6] with the SF-36 cumulative score. In these studies the score was tested by only one quality-of-life instrument thus limiting the possibility of comparison among series.

A wide randomised trial (surgery *versus* medical therapy) by the National Emphysema Treatment Trial [20] recently stated that in upper lobe-located emphysema, surgery can achieve longer survival and a more significant 2-yr improvement in quality of life. Quality of life was assessed by the SGRQ, which is more sensitive in detecting short-term improvements related to changes in respiratory parameters.

GOLDSTEIN *et al.* [3], in a recent randomised study, demonstrated a significant 1-yr improvement of both physical and psychosocial domains after surgery using the Chronic Respiratory Questionnaire, another respiratory-related questionnaire.

According to the present data, SF-36 and SGRQ detected the post-treatment improvement, especially after surgery. In the surgical arm, all domains of the SF-36 except vitality and physical role improved significantly, and with the SGRQ the improvement was significant in all domains regardless of the treatment. An important component is based on the improvement of psychosocial domains as shown by SF-36 social functioning and mental health, and by the SGRQ impact on mood state.

Conversely, neither vitality nor physical role changed significantly. This is probably due to the lack of preoperative rehabilitation in this series and the absence of preconditioning or order effects [21]. Another effect of surgery on social life could be related to the steroid decrement, which is usually observed after lung volume reduction, as already reported by LEYENSON *et al.* [5]. In fact, long-term steroid treatment may negatively affect the behavioural sphere thus influencing psychosocial quality-of-life domains.

Relationships between quality-of-life and functional parameters have been investigated. ANDERSON [22] did not find any relationship among quality-of-life changes after lung volume reduction, measured with the visual analogue scale and the physiological variables. On the contrary, HAMACHER *et al.* [23] showed, in a series of 39 patients undergoing sole surgery, a significant correlation between respiratory (FEV1 and RV/total lung capacity) and exercise performance (6-min walk test) changes and SF-36 physical function. The positive relationship was also observed with social functioning and persisted for up to 2 yrs after surgery.

In a multiple linear regression model, FERRER *et al.* [24] reported that FEV1 % predicted showed the strongest correlation with the SGRQ total score. In a recent report, YUSEN *et al.* [1] demonstrated a strong and lasting correlation between FEV1 and dyspnoea scale score, SF-36 physical function, whereas RV presented only a weak correlation. According to the present data, 6- and 12-month reductions in RV positively affected psychosocial domains, namely SF-36 social functioning and NHP social isolation, while the improvement in FEV1 influenced more the physical ones.

The authors have also observed that physical domains together with dyspnoea index and RV tend to remain significantly improved at 4 yrs after surgery, outlining that the long-lasting effect of the operation is based on the RV decrement. Indeed, they have demonstrated a significant correlation between RV and physical domains starting from 3 yrs after surgery. The authors previously described that RV decrement may improve right ventricular function [25] and nutritional indexes, possibly due to a better use of caloric intake with a significant influence on psychosocial function [26]. Hence, it was hypothesised that the improvement after surgery included both physical and psychosocial improvement and was related to the reduction of mechanical constraints due to lung hyperinflation [5, 7]. This relationship may explain the greater symptomatic improvement that was observed after lung volume reduction since static lung volumes did not change after rehabilitation.

To the best of the authors' knowledge, this is the first randomised controlled trial that has investigated the comparative impact of lung volume reduction and respiratory rehabilitation on quality of life by three different questionnaires. However, the strict selection criteria, difficult randomisation acceptance and the crossover design have limited the sample size available for long-term follow-up. The rehabilitation group presents a lower improvement on quality of life than reported in other studies [10, 20, 21]. Long-term effects were assessable only in the surgical group due to reduction of the rehabilitation group. One further limit may be the heterogeneity of the surgical group, which included patients treated by unilateral and bilateral procedures. Differences in life quality improvement following unilateral and bilateral surgery (data not shown) were not found, and this effect is not due to delayed unilateral operation, which was restricted to one patient. This finding is in contrast with the current finding that one-stage bilateral lung volume reduction allows the maximisation of functional improvements for up to 5 yrs, as recently showed by GELB *et al.* [27]. However, GOLDSTEIN *et al.* [3] did not find any differences between patients treated uni- or bilaterally for any of the quality-of-life measures at baseline and following surgery. This is consistent with the belief that both procedures carry elective indications [7].

To conclude, the authors can state that lung volume reduction or respiratory rehabilitation may significantly improve quality of life, although among surgical patients the improvement was greater, more lasting and involved both physical and psychosocial domains. At 6- and 12-months, correlations of physical domains can be shown with forced expiratory volume in one second changes, whereas, some psychosocial domains are correlated with the residual volume decrement. Furthermore, the positive effect of the lung volume reduction on physical domains, dyspnoea index and residual volume persisted for up to 4 yrs after surgery. This last finding may reinforce the role played by volume reduction in the great symptomatic improvement after surgery.

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