Long-Term Beneficial Effects of Lung Volume Reduction Surgery on Quality of Life in Patients with Chronic Obstructive Pulmonary Disease

YOKO GOTO,^{1,2} MASAHIRO KOHZUKI,² MAKIKO MEGURO² and HAJIME KUROSAWA²

¹Department of Occupational Therapy, School of Health Sciences, Sapporo Medical University, Sapporo, Japan

²Department of Internal Medicine and Rehabilitation Science, Tohoku University Graduate School of Medicine, Sendai, Japan

GOTO, Y., KOHZUKI, M., MEGURO, M. and KUROSAWA, H. *Long-Term Beneficial Effects of Lung Volume Reduction Surgery on Quality of Life in Patients with Chronic Obstructive Pulmonary Disease*. Tohoku J. Exp. Med., 2007, **213** (2), 157-166 — Chronic obstructive pulmonary disease (COPD) is characterized by progressive airflow limitation, which results in exertional dyspnea and physical disability. Subsequently, those cause a difficulty in performing routine activities of daily living and affect their health-related quality of life (HRQOL). Lung volume reduction surgery (LVRS) has been reported to be an effective treatment for selected patients with advanced COPD to improve pulmonary function, lung mechanics, exercise tolerance, and dyspnea. However, the long-term effects of LVRS on HRQOL have not been fully investigated. Therefore the effects of LVRS on generic and disease-specific HRQOL were assessed in patients with COPD following LVRS for 36 months. Nineteen patients (65.1 ± 7.0 [mean $\pm$ S.D.] years old) who underwent pulmonary rehabilitation plus LVRS (LVRS group), and 8 patients (67.2 ± 5.8 years old) who did pulmonary rehabilitation but not LVRS (Medical group) were studied. In both groups, optimal medication was given throughout this period. Generic HRQOL and disease-specific HRQOL were evaluated before rehabilitation, and 3, 12, 24, and 36 months after LVRS. Following LVRS, the generic HRQOL was significantly improved and the disease-specific HRQOL was maintained up to 36 months. In Medical group, disease-specific HRQOL rapidly deteriorated. In conclusion, the long-term effects of LVRS on HRQOL in COPD patients were maintained up to 36 months compared with Medical group. Both generic and disease-specific HRQOL changed differently, suggesting the importance of both assessments especially in long-term follow up. ——— sickness impact profile; visual analogue scale; rehabilitation; lung volume reduction surgery; quality of life
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Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality in the world. The prevalence of COPD was 3.6% in all Japanese subjects (Takemura et al.

2005) and at least 8.6% in the general Japanese population aged over 40 years (Fukuchi et al. 2004); males in their 50s and over 60 years old and females over 60 years old showed remarkably

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Correspondence: Masahiro Kohzuki, M.D., Ph.D., Department of Internal Medicine and Rehabilitation Science, Tohoku University Graduate School of Medicine, 1-1 Seiryō-machi, Aoba-ku, Sendai 980-8574, Japan.
e-mail: kohzuki@mail.tains.tohoku.ac.jp

high prevalence (Takemura et al. 2005). COPD is characterized by progressive airflow limitation which results in exertional dyspnea and physical disability. Subsequently, those cause a difficulty in performing routine activities of daily living and affect their health-related quality of life (HRQOL) (Schenkel et al. 1996; Bendstrup et al. 1997; Goto et al. 2001).

Lung volume reduction surgery (LVRS) has been reported to be an effective treatment for selected patients with advanced COPD to improve pulmonary function, lung mechanics, exercise tolerance, and dyspnea (Keller et al. 1997; Teschler et al. 1999; Geddes et al. 2000; The National Emphysema Treatment Trial Research Group 2003). However, the long-term effects of LVRS on HRQOL have not been fully investigated. In this study, therefore, we investigated whether LVRS would improve generic and disease-specific HRQOL in patients with severe COPD for 36 months.

METHODS

Subjects

Between October 1996 and January 2000, 19 patients with severe COPD aged 65.1 ± 7.0 years (mean $\pm$ S.D.) underwent LVRS in the Tohoku University hospital (LVRS group) were studied. LVRS underwent bilateral simultaneous procedures. In the same period, 8 patients aged 67.2 ± 5.8 years with severe COPD who had equivalent pulmonary impairments that would make them eligible for surgical indication of LVRS, but were medically treated with the pulmonary rehabilitation program without LVRS (Medical group) were studied.

In both groups, high-resolution computed tomography and nuclear-perfusion and ventilation studies were performed to identify the areas of poor function to be targeted for resection, as well as the areas to be avoided. All the patients had radiographic evidence of emphysema and hyperinflation without significant bullous disease. None of the patients in this series had α_1 -antitrypsin deficiency.

The patients who had "target area to be excised" underwent LVRS (LVRS group). The patients who were not accepted for LVRS due to their serious condition were not entered in this study. In Medical group, they had medical reasons of undoing LVRS ($n = 7$) or did not consent to have LVRS ($n = 1$). The medical reasons for

undoing surgical operation were homogenous distribution of emphysematous lesions (i.e., no target areas to be excised) (6 patients), and relatively younger age (1 patient).

Intensive medical treatment with a pulmonary rehabilitation program was started in both groups, and continued until the operation (LVRS group) or discharge (Medical group). The pulmonary rehabilitation programs were same content in two groups. They were mainly based on exercise training such as walking and cycle ergometry, and also included breathing pattern training (pursed lips and diaphragmatic breathing), thoracic-mobility exercise, stress management, and educational sessions using videotapes (medication, oxygen therapy, nutrition, and health preservation). The study was approved by the appropriate institutional review boards, and written informed consent was obtained from all of the subjects.

Pulmonary functions, body weight and exercise capacity

Spirometry was performed using standard techniques (American Thoracic Society 1995) and apparatus (Fudac-70S; Fukuda Denshi Co., Tokyo). Lung volume was estimated using body plethysmography (Gould 2800J; Gould, Dayton, OH, USA). Arterial blood was sampled from the radial artery in the sitting position during room air breathing. Body weight expressed as % ideal body weight (% IBW). Functional exercise performance was measured by a 6-minute walking distance (6MWD), which is the conventional manner that Guyatt et al. (1984) described.

HRQOL

HRQOL was assessed with use of Sickness Impact Profile (SIP) (Bergner et al. 1981) for generic HRQOL, and by visual analogue scale (VAS) (Hiratsuka and Kida 1993) for disease-specific QOL.

SIP is one of the well known generic HRQOL measure and is a sensitive and behaviorally based measure of sickness-related dysfunction (Bergner et al. 1981). The SIP contains 136 items grouped into 12 categories (A, ambulation; M, mobility; BCM, body care and movement; SM, social interaction; C, communication; AB, alertness behavior; EB, emotional behavior; SR, sleep and rest; E, eating; HM, home management; RP, recreation and pastimes; W, working) describing activities involved in carrying on one's life, and reflects the self-assessment of the sickness and dysfunction, in which the score ranges from 0% (indicating high HRQOL) to 100%

(indicating low HRQOL) (Bergner et al. 1981).

There are two overall dimensions (the physical dimension score calculated from 3 categories related to motor activities, and the psychosocial dimension score calculated from 4 categories related to emotional and social behaviors) and 5 independent categories that is not a separate dimension but is included in the total SIP score (Bergner et al. 1981). We made the Japanese version of SIP by back translation method and obtained permission to use it from the original investigators.

VAS is a simple HRQOL questionnaire using a linear analog scale designed to evaluate HRQOL in patients with chronic pulmonary diseases (Hiratsuka and Kida 1993). It was previously shown that the QOL scale has internal consistency and validity (Hiratsuka and Kida 1993; Katsura et al. 2003). VAS showed a significant correlation with the total score and three components of the St. George's Respiratory Questionnaire (Jones et al. 1992), the other disease-specific HRQOL measure for patients with chronic pulmonary diseases. VAS scale contains 7 items (Feeling of Well-being, Mood, Dyspnea, Social Activities, Housework or Job, Appetites, Anxiety). One hundred millimeter vertical line was given for each item, with the ends of the lines labeled with words descriptive of item. The examinee was asked to write a simple mark (x) on the line at the point most appropriate to describe their feelings at that moment. The scores

ranges were from the best score (100 mm = 100%) to the worst score (0 mm = 0%) (Hiratsuka and Kida 1993).

Timing of the measurements

In both groups, pulmonary function and exercise capacity were evaluated before rehabilitation. Pulmonary function and exercise capacity were also evaluated before rehabilitation and 3, 12 and 36 months after LVRS. Pulmonary function and exercise capacity in Medical group were evaluated only at the beginning of this study because we could not examine after their discharge from the hospital. HRQOL were evaluated before rehabilitation and 3, 12, 24 and 36 months after LVRS (LVRS group), or at approximately the same time starting from the day of discharge instead of from the day of operation (Medical group). Three of 19 patients in the LVRS group could not be evaluated SIP at 3 months after LVRS for being in hospital, because SIP contained several categories concerned items at home.

Data analysis

All data are presented as mean $\pm$ s.d. Comparisons between LVRS group and Medical group were performed by two-way repeated measures ANOVA with α set at $p < 0.05$. Comparisons within a group were performed by a one-way repeated measures ANOVA following by Tukey's multiple-comparison post hoc test, with α set at

TABLE 1. Characteristics of LVRS and Medical group at pulmonary functions and exercise performance.

	LVRS group ($n = 19$)	Medical group ($n = 8$)
Sex (male : female)	M : F = 18 : 1	M : F = 8 : 0
Age (yrs)	67.2 $\pm$ 5.8	65.1 $\pm$ 7.0
Pulmonary functions		
FEV1 (l)	0.68 $\pm$ 0.19	0.94 $\pm$ 0.47
VC (l)	2.23 $\pm$ 0.62	2.85 $\pm$ 1.19
FVC (l)	1.86 $\pm$ 0.57	2.43 $\pm$ 1.11
PaO ₂ (Room air) (mmHg)	64.5 $\pm$ 8.7	72.4 $\pm$ 11.7
PaCO ₂ (Room air) (mmHg)	46.3 $\pm$ 9.3	47.2 $\pm$ 9.4
% IBW (%)	85.9 $\pm$ 12.3	92.0 $\pm$ 7.5
6WMD (m)	277.9 $\pm$ 102.9	236.9 $\pm$ 115.9
Oxygen at rest (n)	9	4
Oxygen (l/min)	1.8 $\pm$ 1.3	3.1 $\pm$ 2.2

(mean $\pm$ s.d.)

FEV1, forced expiratory volume in one second; VC, vital capacity; FVC, forced vital capacity; IBW, ideal body weight.

$p < 0.05$. All statistical analysis was performed using a commercially available computer-based software program (Stat View-J 4.05, Abacus Concepts, Inc., USA).

RESULTS

Baseline measurements

At the baseline evaluation, there were no significant differences in pulmonary functions, and exercise capacity (Table 1), and VAS and SIP HRQOL scores (Table 2), between LVRS and Medical group.

Effects of LVRS on pulmonary function and 6-minute walking distance (6MWD)

Some of patients in the LVRS group could be evaluated for pulmonary functions ($n = 9$) and 6MWD ($n = 7$) before rehabilitation and 3, 12 and 36 months after LVRS. The change of FEV₁ was 0.74L (before rehabilitation), 1.20L (3 months), 1.02L (12 months), 0.96L (36 months). FEV₁ increased by 62% at 3 months post-LVRS, 37% (12 months) and 30% (36 months), compared to the preoperative baseline values. The result of 6MWD at 3 months was significantly increased by 28%, and the increase was maintained at the 36 month follow-up in LVRS group.

Effects of LVRS on HRQOL

Fig. 1 shows the SIP HRQOL scores by SIP in both groups during 36 months. Statistically significant interaction of time and group by two-way repeated measures ANOVA was found in SIP-overall: ($p < 0.01$), and SIP-physical: ($p < 0.05$), and tendency of interaction of time and group was found in SIP-psychosocial ($p = 0.054$). In the LVRS group, the SIP-overall, SIP-physical and SIP-psychosocial score were significantly improved after LVRS for 36 months. Both SIP-overall and SIP-physical scores were significantly improved at 12 months after LVRS, and maintained until 36 months compared to the baseline. The SIP-psychosocial score was also improved similarly, but the statistical significance was found only at 12 months compared to the baseline. In the Medical group, the SIP-overall and SIP-physical scores were significantly deteriorated for 36 months. Especially, the SIP-overall score at 36

TABLE 2. HRQL baseline data of LVRS and Medical group.

	SIP			VAS						
	Overall	Physical	Psychosocial	Feeling of Well-being	Mood	Dyspnea	Social Activities	Housework or Job	Appetites	Anxiety
LVRS group (<i>n</i> = 19)	27.6 ± 13.9	21.5 ± 17.0	23.3 ± 16.6	70.8 ± 21.4	75.0 ± 20.8	74.1 ± 20.8	30.2 ± 35.5	46.4 ± 36.9	69.1 ± 26.4	66.4 ± 29.1
Medical group (<i>n</i> = 8)	30.0 ± 20.0	24.3 ± 21.7	25.0 ± 21.2	68.0 ± 24.6	80.1 ± 18.0	86.9 ± 16.9	57.0 ± 37.8	50.5 ± 38.7	81.9 ± 17.7	74.3 ± 30.9
<i>p</i> -value	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

HRQOL, health-related quality of life; LVRS, lung volume reduction surgery; SIP, sickness impact profile; VAS, visual analogue scale.

Fig. 1. SIP-HRQOL scores in two groups for 36 months.

The Sickness Impact Profile (SIP) scores are shown on the upper (LVRS group) and lower (Medical group) panels. Mean scores of SIP-Overall (left), SIP-Physical (center), and SIP- Psychosocial (right) in LVRS group ($n = 19$), and Medical group ($n = 8$).

Data are expressed as mean $\pm$ s.d. Each bars indicates the mean SIP scores (0-100%) of the baseline ($n = 19$), 3 months ($n = 16$), and 12, 24, 36 months ($n = 19$) after LVRS. As described in the text, higher points indicate a lower level of HRQOL.

Statistically significant interaction of time and group by two-way repeated measures ANOVA was found in. SIP-overall: ($p < 0.01$), and SIP-physical: ($p < 0.05$), and tendency of interaction of time and group was found in SIP-psychosocial ($p = 0.054$).

* $p < 0.05$, *** $p < 0.001$, by one way repeated measures ANOVA within each group. ^a $p < 0.05$ compared to baseline, and ^b $p < 0.05$ compared to 3 month score, by Tukey's multiple-comparison post hoc test.

■, (base line); ▨, (3 month); □, (12 month); ▤, (24 month); ▩, (36 month).

Fig. 2. SIP-HRQOL scores in two groups for 36 months.

Twelve categories comprise SIP. The category scores are shown on the upper (LVRS group) and below (Medical group) panels. The Physical Dimension is composed of 3 categories (A: ambulation, M: mobility, BCM: body care and movement). The Psychosocial Dimension Score is composed of 4 categories (SI: social interaction, C: communication, AB: alertness behavior, EB: emotional behavior), and is added to other 5 independent categories (SR: sleep and rest, E: eating, HM: home management, RP: recreation and pastimes, W: working). Data are expressed as mean $\pm$ S.D. Each bars indicates the mean category scores (0-100%) of the baseline ($n = 19$), 3 months ($n = 16$), and 12, 24, 36 months ($n = 19$) after LVRS. As described in the text, higher points indicate a lower level of HRQOL.

Statistically significant interaction of time and group by two-way repeated measures ANOVA was found in BCM ($p < 0.001$), and SI ($p < 0.01$), and tendency of interaction of time and group was found in A ($p = 0.056$) and HM ($p = 0.069$).

* $p < 0.05$, *** $p < 0.001$, by one way repeated measures ANOVA within each group. ^a $p < 0.05$ compared to baseline, and ^b $p < 0.05$ compared to 3 month score, by Tukey's multiple-comparison post hoc test.

A, ambulation; M, mobility; BCM, body care and movement; SI, social interaction; C, communication; AB, alertness behavior; EB, emotional behavior; SR, sleep and rest; E, eating; HM, home management; RP, recreation and pastimes; W, working

■, (base line); ▨, (3 month); □, (12 month); ▩, (24 month); ▤, (36 month).

A. LVRS group

B. Medical group

Fig. 3. VAS-HRQOL scores in two groups for 36 months.

The visual analogue scale (VAS)–HRQOL scores are shown on the left (LVRS group, $n = 19$) and right (Medical group, $n = 8$) panels. Data are expressed as mean $\pm$ S.D. Each bars indicates mean scores (0–100%) of 7 items (Feeling of Well-being, Mood, Dyspnea, Social Activities, Housework or Job, Appetites, Anxiety).

Statistically significant interaction of time and group by two-way repeated measures ANOVA was found in. Mood: ($p < 0.01$), Dyspnea: ($p < 0.0001$), Social Activities ($p = 0.001$), Housework or Job: ($p < 0.01$) and Appetites ($p < 0.0001$).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, by one way repeated measures ANOVA within each group.

^a $p < 0.05$ compared to baseline, and ^b $p < 0.05$ compared to 3 month score, ^c $p < 0.05$ compared to 12 month score, by Tukey's multiple-comparison post hoc test. As described in the text, higher points indicate a higher level of HRQOL.

■, (base line); ▨, (3 month); □, (12 month); ▤, (24 month); ▩, (36 month).

months significantly deteriorated compared to 12 months.

Fig. 2 shows characteristics of 12 category scores composing of SIP in both groups. Statistically significant interaction of time and group by two-way repeated measures ANOVA was found in BCM ($p < 0.001$), and SI ($p < 0.01$), and tendency of interaction of time and group was found in A ($p = 0.056$) and HM ($p = 0.069$). In the LVRS group, the physical dimension score from 3 categories (ambulation, mobility, body care and movement), two in 4 categories of the psychosocial dimension score (social interaction, emotional behaviors), and one in 5 independent categories (home management) were improved significantly after LVRS. In the Medical group, one category (mobility) of the physical dimension score has gradually deteriorated for 36 months.

Fig. 3 shows VAS-HRQOL scores by visual analogue scale in both groups during 36 months. The VAS-HRQOL was the best at 12 months. Statistically significant interaction of time and group by two-way repeated measures ANOVA was found in Mood: ($p < 0.01$), Dyspnea: ($p < 0.0001$), Social Activities ($p = 0.001$), Housework or Job: ($p < 0.01$) and Appetites ($p < 0.0001$). In the LVRS group, seven in 9 items (Feeling of Well-being, Mood, Social Activities, Housework or Job, Anxiety) were significantly changes for 36 months. Social Activities, Housework or Job, and Anxiety scores at 12 month were significantly improved compared to the baseline, but Feeling of Well-being and Mood scores at 36 month became significantly worse than 12 months. In Medical group, VAS-HRQOL scores were the best at the baseline and became gradually worse afterwards.

DISCUSSION

The present study demonstrated that the generic SIP-HRQOL in LVRS group improved and also the disease-specific VAS-HRQOL in LVRS was maintained up to 36 months after the operation. This study indicated that the long-term beneficial effects of LVRS on generic and disease-specific HRQOL in severe COPD patients. Moreover, this study also demonstrated that the

generic SIP-HRQOL in Medical group improved only temporary after pulmonary rehabilitation and also the disease-specific VAS-HRQOL was rapidly deteriorated in Medical group.

The SIP measures the effective activities involved in carrying on one's life, and reflects the self-assessment of the sickness and dysfunction (Bergner et al. 1981). Criner et al. (1999) suggested that a substantial improvement in SIP-HRQOL 3 months after LVRS compared with pulmonary rehabilitation alone. Cordova et al. (1997) also reported that the SIP-overall score improved at 3 months after LVRS and was sustained for 12 months. Moreover, O'Brien et al. (1999) reported that patients with moderate to severe resting hypercapnia also had significantly improved SIP scores between 3 and 6 months after LVRS. In the present study, we observed an improvement in SIP scores up to 36 months after LVRS. Especially, marked improvement in the SIP-Physical score was apparent in LVRS group. The SIP-Physical score at 12 months after LVRS improved to almost the same level as the normal range reported by Prigatano et al. (1984).

In contrast, HRQOL scores in Medical group were gradually deteriorated in this study. However, there was still a possible benefit of SIP-HRQOL during the initial 3 months in Medical group, probably due to in-patient pulmonary rehabilitation. Randomized control trials as National Emphysema Treatment Trial (NETT) study reported that the pulmonary rehabilitation before LVRS also showed significant improvements on QOL measure (Kaplan et al. 2004).

There were different changes in the SIP-HRQOL level between LVRS group and Medical group for 36 months. Therefore the present study indicated that, in selected patients, LVRS had a beneficial impact on generic HRQOL that could not be achieved by conservative therapies such as medical treatment and pulmonary rehabilitation.

In contrast to the marked improvement in the SIP-physical score in LVRS group, improvement in the SIP-psychosocial score was not so apparent. We also reported that the psychological state scores did not significantly change up to 12 months after LVRS compare to the baseline (Goto

et al. 2004). Previous studies also showed that LVRS did not significantly improve the psychological evaluation scores, for examples, in the emotional reaction and mental health scores of the Nottingham Health Profile (NHP) by Cooper et al. (1996), nor in the role emotional and mental health scores of SF-36 by Moy et al. (1999). Therefore, beneficial effects of LVRS on psychosocial HRQOL might be not so strong compared with those on physical HRQOL in severe COPD patients.

The present study demonstrated that most of the disease-specific VAS-HRQOL scores in LVRS were maintained up to 36 months after the operation compared with Medical group. However, both of Feeling of Well-being and Mood at 36 months after LVRS were worse than before LVRS. It is difficult to elucidate the reason why the VAS-HRQOL did not improve significantly after LVRS. One of the reasons may be that COPD is the progressive disease, and it is difficult for COPD patients to expect long lasting beneficial effects of LVRS. Indeed, lung function appears to improve in the first few months following LVRS in most patients, maximizing at approximately 3 to 6 months and declining thereafter (Brenner et al. 1998; Goto et al. 2004).

VAS-HRQOL was rapidly deteriorated in Medical group. Similar results were reported by Oga et al. (2004) that the dyspnea, fatigue, and emotional function domains of the Chronic Respiratory Disease questionnaire declined slowly but significantly over 3 years in COPD patients.

The limitation of this study is that, there could have been a bias in the selection of patients for operation since it was not a randomized trial. However, LVRS is not an appropriate therapy for all patients with COPD (Weinmann and Hyatt 1996; The National Emphysema Treatment Trial Research Group 2003). There is a category of patients for whom LVRS has been demonstrated to provide significant benefit and there are ethical problems regarding randomization for those categorized patients (Cooper 2001). The surgical indications for LVRS should be carefully considered in each case. Therefore, we did not have randomized settings in the present study.

Another limitation was the small number of the patients. The number of new patients to our hospital was less than we expected during the scheduled period. Although our findings were significant, still the supportive reports by the future studies will be needed.

In conclusion, the long-term effects of LVRS on HRQOL in COPD patients were maintained up to 36 months compared with Medical group. Both generic and disease-specific HRQOL changed differently, suggesting the importance of both assessments especially in long-term follow up.

In conclusion, the long-term beneficial effects of LVRS on generic and disease-specific HRQOL in COPD patients were demonstrated. The present results indicated that the generic HRQOL in LVRS group improved and also the disease-specific HRQOL in LVRS was maintained up to 36 months after the operation. Both generic and disease-specific HRQOL changed differently, suggesting the importance of both assessments especially in long-term follow up.

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References

- American Thoracic Society (1995) Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. *Am. Respir. Crit. Care Med.*, **152**, S77-S120.
- Bendstrup, K.E., Jensen, J.I., Holm, S. & Bengtsson, B. (1997) Out-patient rehabilitation improves activities of daily living, quality of life and exercise tolerance in chronic obstructive pulmonary disease. *Eur. Respir. J.*, **10**, 2801-2806.
- Bergner, M., Bobbitt, R.A., Carter, W.B. & Gilson, B.S. (1981) The sickness impact profile: development and final revision of a health status measure. *Med. Care*, **19**, 787-805.
- Brenner, M., McKenna, Jr., R.J., Gelb, A.F., Fischel, R.J. & Wilson, A.F. (1998) Rate of FEV1 change following lung volume reduction surgery. *Chest*, **113**, 652-659.
- Cooper, J.D., Patterson, G.A., Sundaresan, R.S., Trulock, E.P., Yusem, R.D., Pohl, M.S. & Lefrak, S.S. (1996) Results of 150 consecutive bilateral lung volume reduction surgery in patients with severe emphysema. *J. Thorac. Cardiovasc. Surg.*, **112**, 1319-1330.
- Cooper, J.D. (2001) Paying the piper: The NETT strikes a sour note. *Ann. Thorac. Surg.*, **72**, 330-333.
- Cordova, F., O'Brien, G., Furukawa, S., Kuzma, A.M., Travaline, J. & Criner, G.J. (1997) Stability of improve-

- ments in exercise performance and quality of life following bilateral lung volume reduction surgery in severe COPD. *Chest*, **112**, 907-915.
- Criner, G.J., Cordova, F.C., Furukawa, S., Kuzma, A.M., Travaline, J.M., Leyenson, V. & O'Brien, G.M. (1999) Prospective randomized trial comparing bilateral lung volume surgery to pulmonary rehabilitation in severe chronic obstructive pulmonary disease. *Am. J. Respir. Crit. Care Med.*, **160**, 2018-2027.
- Fukuchi, Y., Nishimura, M., Ichinose, M., Adachi, M., Nagai, A., Kuriyama, T., Takahashi, K., Nishimura, K., Ishioka, S., Aizawa, H. & Zaher, C. (2004) COPD in Japan: the Nippon COPD epidemiology study. *Respirology*, **9**, 458-465.
- Geddes, D., Davies, M., Koyama, H., Hansell, D., Pastorino, U., Pepper, J., Agent, P., Cullinan, P., MacNeill, S.J. & Goldstraw, P. (2000) Effect of lung-volume-reduction surgery in patients with severe emphysema. *N. Engl. J. Med.*, **343**, 239-245.
- Goto, Y., Kohzaki, M., Watanabe, M., Mori, N. & Kurosawa, H. (2001) Improved Activities of Daily Living (ADL), Quality of Life (QOL) and Psychological Status following Lung Volume Reduction Surgery (LVRS) for Emphysema. *The 1st World Congress of the International Society of Physical and Rehabilitation medicine (ISPRM I)*. Bologna: Monduzzi, Editore, 837-840.
- Goto, Y., Kurosawa, H., Mori, N., Kurokawa, Y., Hida, W. & Kohzaki, M. (2004) Improved activities of daily living, psychological state and health-related quality of life for 12 months following lung volume reduction surgery in patients with severe emphysema. *Respirology*, **9**, 337-344.
- Guyatt, G.H., Pugsley, S.O., Sullivan, M.J., Thompson, R.J. & Berman, L. (1984) Effects of encouragement in walking test performance. *Thorax*, **39**, 818-822.
- Hiratsuka, T. & Kida, K. (1993) Quality of life measurement using a linear analog scale for elderly patients with chronic lung disease. *Intern. Med.*, **32**, 832-836.
- Jones, P.W., Quirk, F.H., Baveystock, C.M. and Littlejohns, P. (1992) A self-complete measure of health status for chronic airflow limitation: The St. George's Respiratory Questionnaire. *Am. Rev. Respir. Dis.*, **145**, 1321-1327.
- Kaplan, R.M., Ries, A.L., Reilly, J. & Mohsenifar, Z. (2004) Measurement of health-related quality of life in the national emphysema treatment trial. *Chest*, **126**, 781-789.
- Keller, C.A., Ruppel, G., Hibbett, A., Osterloh, J. & Naunheim, K.S. (1997) Thoracoscopic lung volume reduction surgery reduces dyspnea and improves exercise capacity in patients with emphysema. *Am. J. Respir. Crit. Care Med.*, **156**, 60-67.
- Katsura, H., Yamada, K. & Kida, K. (2003) Usefulness of a linear analog scale questionnaire to measure health-related quality of life in elderly patients with chronic obstructive pulmonary disease. *J. Am. Geriatr. Soc.*, **51**, 1131-1135.
- Moy, M.L., Ingenuity, E.P. & Minter, S.J. (1999) Health-related quality of life improves following pulmonary rehabilitation and lung volume reduction surgery. *Chest*, **115**, 383-389.
- O'Brien, G.M., Fukuhara, S., Kuzma, A.M., Cordova, F. & Criner, G.J. (1999) Improvements in lung function, exercise, and quality of life in hypercapnic COPD patients after lung volume reduction surgery. *Chest*, **115**, 75-84.
- Oga, T., Nishimura, K., Tsukino, H., Hajiro, T., Sato, S., Ikeda, A., Hamada, C. & Mishima, M. (2004) Longitudinal changes in health status using the Chronic Respiratory Disease Questionnaire and pulmonary function in patients with stable Chronic Obstructive Pulmonary Disease. *Quality of Life Research*, **13**, 1109-1116.
- Prigatano, G.P., Wright, E.C. & Levin, D. (1984) Quality of life and its predictors in patients with mild hypoxemia and chronic obstructive pulmonary disease. *Arch. Intern. Med.*, **144**, 1613-1619.
- Schenkel, N.S., Burdet, L., Muralt, B. & Fitting, J.W. (1996) Oxygen saturation during daily activities in chronic obstructive pulmonary disease. *Eur. Respir. J.*, **9**, 2584-2589.
- Takemura, H., Hida, W., Sasaki, T., Sugawara, T. & Sen, T. (2005) Prevalence of Chronic Obstructive Pulmonary Disease in Japanese People on Medical Check-Up. *Tohoku J. Exp. Med.*, **207**, 41-50.
- Teschler, H., Thompson, A.B. & Stamatis, G. (1999) Short- and long-term functional results after lung volume reduction surgery for severe emphysema. *Eur. Respir. J.*, **13**, 1170-1176.
- The National Emphysema Treatment Trial Research Group. (2003) A randomized trial comparing lung volume reduction surgery with medical therapy for severe emphysema. *N. Engl. J. Med.*, **348**, 2059-2073.
- Weinmann, G.G. & Hyatt, R. (1996) Evaluation and research in lung volume reduction surgery. *Am. J. Respir. Crit. Care Med.*, **154**, 1913-1918.