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Clinical evaluation of ^{99m}Tc-Technegas SPECT in thoracoscopic lung volume reduction surgery in patients with pulmonary emphysema

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^{99m}Tc-Technegas (Tcgas) SPECT is useful for evaluating the patency of the airway and highly sensitive in detecting regional pulmonary function in pulmonary emphysema. The aim of this study is to evaluate regional ventilation impairment by this method pre and post thoracoscopic lung volume reduction surgery (LVRS) in patients with pulmonary emphysema. ***Methods:*** There were 11 patients with pulmonary emphysema. The mean age of patients was 64.1 years. All patients were males. LVRS was performed bilaterally in 8 patients and unilaterally in 3 patients. Post inhalation of Tcgas in the sitting position, the subjects were placed in the supine position and SPECT was performed. Distribution of Tcgas on axial images was classified into 4 types, A: homogeneous, B: inhomogeneous, C: hot spot, D: defect. Three slices of axial SPECT images, the upper, middle and lower fields were selected, and changes in deposition patterns post LVRS were scored (Tcgas score). ***Results:*** Post LVRS, dyspnea on exertion and pulmonary function tests were improved. Pre LVRS, inhomogeneous distribution, hot spots and defects were observed in all patients. Post LVRS, improvement in distribution was obtained not only in the surgical field and other fields, but also in the contralateral lung of unilaterally operated patients. In 5 patients some fields showed deterioration. The Tcgas score correlated with improvements in $FEV_{1.0}$, $FEV_{1.0}$% and %$FEV_{1.0}$. ***Conclusion:*** Tcgas SPECT is useful for evaluating changes in regional pulmonary function post LVRS.

Key words: ^{99m}Tc-Technegas, SPECT, pulmonary emphysema, lung volume reduction surgery, thoracoscopic surgery

INTRODUCTION

VOLUME REDUCTION SURGERY (LVRS) has recently been indicated for pulmonary emphysema, which was previously treated only with conservative therapy with medication.[1–4] Since about 1990, a number of studies have reported that thoracoscopic volume reduction surgery relieves symptoms and improve pulmonary function.[5–7] Postoperative pulmonary function is often evaluated by pulmonary function tests, but these tests reveal whole pulmonary function, and so examination with radioisotopes is most suitable for the evaluation of regional pulmonary function. Tc-99m-Technegas (Tcgas) (carbon microparticles labeled with Tc-99m) can be used for imaging of regional pulmonary ventilation on the basis of its alveolar deposition post inhalation. Three-dimensional Tcgas imaging with SPECT is also available.[8] To evaluate the usefulness of Tcgas, regional pulmonary function was investigated with Tcgas inhalation SPECT performed pre and post thoracoscopic LVRS in patients with pulmonary emphysema.

This study was designed to evaluate the usefulness of Tcgas for LVRS in 11 patients with pulmonary emphysema. Before the study, the nature of the study was fully explained to the patients and their informed consent was properly obtained.

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Table 1 Clinical symptom and pulmonary function tests pre and post LVRS

Case No.	Age	DOE (F-H-J)		Pulmonary Function Tests									
				PaO_2 (mmHg)		VC (%)		$FEV_{1.0}$ (ml)		$FEV_{1.0}$ (%)		%$FEV_{1.0}$	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	54	3	3	79.6	74.9	122.3	86.9	2090	1750	53.3	57.2	71.4	59.8
2	58	4	1	64.0	70.1	62.0	80.7	710	1860	33.5	68.1	15.5	40.7
3	66	4	3	54.1	72.0	53.0	64.1	570	630	30.5	28.0	11.9	22.4
4	68	3	1	65.8	79.5	84.8	96.9	820	1910	35.0	62.6	36.3	84.6
5	65	3	2	62.2	66.1	64.5	77.7	650	940	34.2	42.2	29.2	42.3
6	65	3	2	62.6	68.9	67.8	68.8	660	810	28.6	32.9	22.4	27.5
7	73	3	1	86.0	90.0	83.1	73.1	1520	1950	53.0	74.7	55.6	71.3
8	65	4	2	75.0	78.0	76.0	79.1	870	960	35.8	38.7	40.2	44.4
9	66	3	2	70.9	74.4	75.3	80.7	800	820	31.8	30.5	31.6	32.4
10	60	4	3	102.3⊗	52.4	56.9	41.6	540	810	32.9	62.3	21.6	32.4
11	65	4	3	59.1	80.9⊗	61.7	66.5	490	660	29.9	31.9	10.9	14.7
Mean	64.1	**3.5	**2.1	*68.9	*75.2	73.4	74.2	*884	*1191	*36.2	*48.1	*31.5	*43.0
SD	5.1	0.5	0.8	9.9	7.3	19.2	14.3	488	547	8.7	17.1	18.8	21.2

DOE = Dyspnea on exertion, F-H-J = Frecher-Hugh-Jones classification, Pre = Pre LVRS, Post = Post LVRS, ⊗= Oxygen inhalation case, ** = $p < 0.01$, * = $p < 0.05$

SUBJECTS AND METHODS

The subjects consisted of 11 male patients with pulmonary emphysema aged between 54 and 73 years (mean, 64.1 years). Six cases out of 11 had bulla. LVRS was performed in all patients; bilateral surgery in 8 and unilateral surgery in 3 (cases Nos. 9 and 10: left lung, case No. 11: right lung). Bullectomy was performed in 6 patients and pneumectomy and laser ablation in all patients (Table 1).

Preparation and Inhalation of Tcgas

Tcgas consisting of microparticles with a diameter of 5 nm was produced in a Tcgas generator (Tetley Technologies) filled with argon gas, where sodium pertechnetate in normal saline was inserted into a graphyte crucible and heated to 2500°C. Patients sitting with a nose clip on were instructed to inhale Tcgas several times through a 1-meter tube from functional residual capacity (FRC) to total lung capacity (TLC). To obtain an adequate pulmonary deposition of Tcgas, patients were also instructed to stop breathing for about 3–5 seconds at the TLC level. Post inhalation of Tcgas at a level of about 200,000 counts/min, SPECT was performed in the supine position. The gamma camera used was MULTISPECT3 (Siemens) with parallel-type, low-energy, high-resolution collimators. SPECT images obtained with a matrix size of 128 by 128, step angle of 4°, acquisition time of 40 sec and 90 acquisition directions were synthesized without attenuation correction to reconstruct 3 slices which were then combined into one axial image (10.5 mm in total).

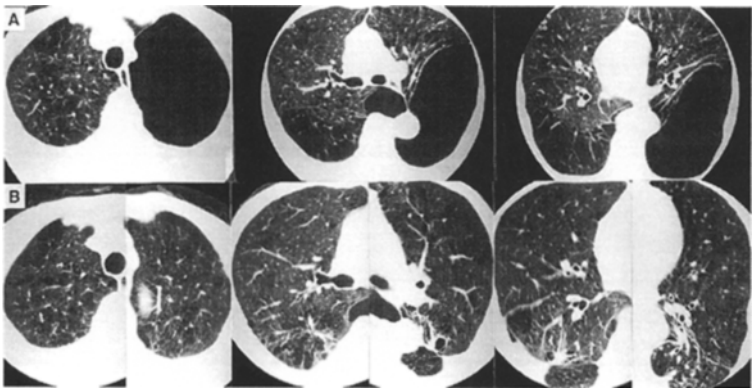
Case Presentation

Case no. 4 A 66-year-old male was treated with bilateral bullectomy and pneumectomy.

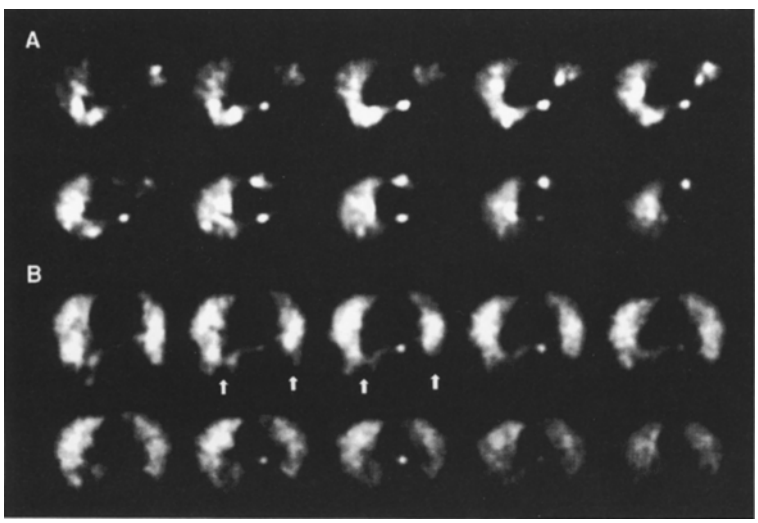
The patient had exertional dyspnea, severe obstructive ventilatory disturbance of a obstructive disorder and hypoxemia. With CT and Tcgas findings bilateral lower lung lobes were targeted for volume reduction (Fig. 1aA, 1bA). LVRS was performed as video-assisted thoracoscopic surgery (VATS). Surgical reduction of lung volume (the left lung from the base to S6 and the right lung from S6 to S9) was achieved uniformly through serial nonsegmental wedge resection with a 45 mm thoracoscopic linear cutter. After resection by stapler, emphysematous tissue was laser-ablated. Post LVRS, CT showed the expansion of compressed residual lung lobes and distribution of Tcgas improved remarkably. In dorsal bilateral lower lung lobes, CT identified normal lung structure, but Tcgas showed defects indicating ventilation disorder (Fig. 1aB, 1bB⇧). The degree of dyspnea, pulmonary function and PaO_2 improved.

Case no. 11 A 65-year-old male was treated with right pneumectomy.

The patient had severe exertional dyspnea and mixed ventilatory disturbance of restrictive and obstructive disorders. Plain chest X-ray showed hyperlucent bilateral lung fields especially in the bilateral lower fields. CT images showed low attenuation areas, especially in the upper and lower lung fields. Nevertheless, Tcgas SPECT showed severe inhomogeneity with hot spots and defects particularly in the right lung (Fig. 2aA, 2b, 2cA). LVRS was performed on the right lung (S2 to the apex, middle lobe and base). After resection by stapler, emphysematous tissue was laser-ablated. Post LVRS, chest X-ray showed decreases in volume and radiolucency of the right lung. Tcgas images homogeneity improved not only in the surgical lung but also in the contralateral lung (Fig. 2aB, 2cB). The degree of dyspnea and pulmonary function improved.



1a



1b

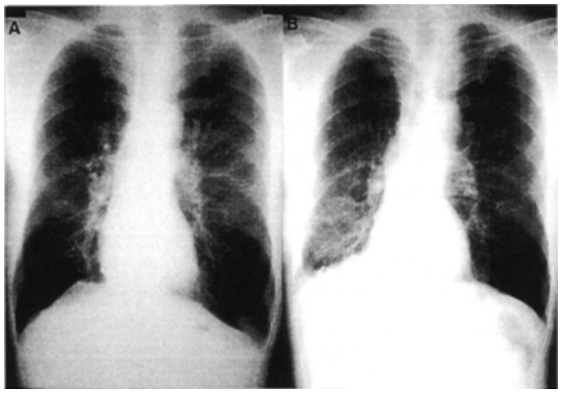
Fig. 1
a. Pre LVRS, chest CT demonstrated multiple low attenuation areas (LAA) in bilateral lungs and giant bulla in the left lung middle and lower field (A). Post LVRS, CT showed the disappearance of cystic lesions and expansion of compressed residual lung lobes (B).
b. Pre LVRS, axial images of Tcgas SPECT show severe inhomogeneity with hot spots and defects in bilateral lungs. Especially, Tcgas deposition was negligible in the left lung (A, lower to upper slices). Post LVRS, although inhomogeneity still remained, no hot spots or marked defects were detectable. A remarkable improvement of homogeneity was observed. But, in a dorsal bilateral lower lung lobes, Tcgas showed defects (B⇧).

Scoring of Pulmonary Tcgas Distribution
A scoring method was developed to compare pre and post LVRS distributions of Tcgas in axial SPECT images. Three slices were chosen for this purpose: an upper slice at the middle of the trachea, a middle slice just below the carina and a lower slice equidistant between the carina and base. Tcgas distribution in each slice was classified into 4 types according to our simplified classification for pulmonary Tcgas planar images.[12] Postoperative improvement of 1 type (e.g. from type C to type B) was scored +2 points. Deterioration of 1 type was scored −2 points. A slight improvement (e.g. reduction of inhomogeneity in type B was named type B+, reduction of hot spots in type C was named type C+, reduction of defects area in type D was named type D+) was scored +1 point. A slight deterioration (e.g. increase of inhomogeneity in type B was named type B−, increase of hot spots in type C was named type C−, increase in defects area in type D was named type D−) was scored −1 point (Fig. 3).

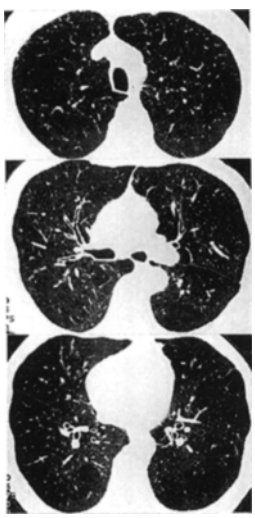
RESULTS

Tcgas Deposition Patterns and Tcgas Scores
Pre LVRS, inhomogeneous distribution and hot spots were observed and the proportion of types C and D deposition patterns was high. Post LVRS, distribution of Tcgas showed improvement or no change in any slice in 6 of 11 patients and deterioration was not observed. But in 5 patients deposition patterns were partially deteriorated (Table 2). The Tcgas score for whole lung and bilateral lungs improved in all patients. Tcgas distribution and Tcgas scores in the contralateral lung improved postoperatively in all 3 patients who underwent unilateral LVRS (Fig. 4).

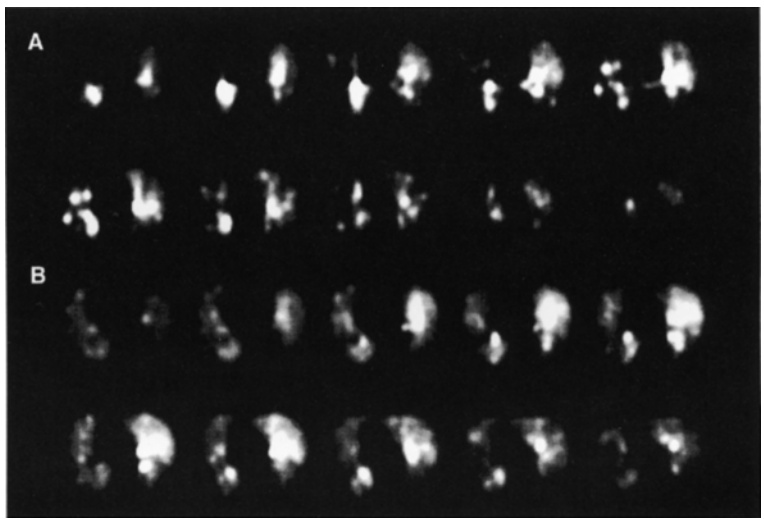
Changes in Pulmonary Function Tests Post LVRS
Pulmonary function tests pre surgery showed severe obstructive or mixed ventilatory impairment in all patients. Clinical symptoms evaluated by the F-H-J classification improved in 10 patients (90.9%) but showed no change in one patient (9.1%). In 9 patients who underwent blood gas analysis without the assistance of oxygen therapy, PaO_2 improved in 8 patients (89%). As for other variables,



2a



2b



2c

Fig. 2
a. Pre LVRS, plain chest X-ray showed overinflation and hyperlucent bilateral lung fields especially in the lower fields (A). Post LVRS, chest X-ray showed decreases in volume and radiolucency of the right middle lower lung field (B).
b. Pre LVRS, entire bilateral lungs CT images showed low attenuation areas, especially in the upper and lower lung fields.
c. Pre LVRS, Tcgas SPECT axial images showed severe inhomogeneity with hot spots and defects particularly in the right lung (A, lower to upper slices). Post LVRS, Tcgas distribution was improved. Homogeneity improved in the contralateral lung (B).

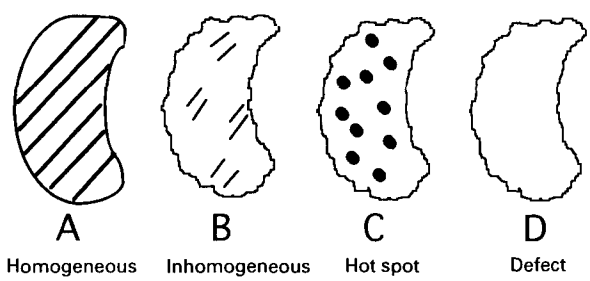


Fig. 3 Scoring of pulmonary Tcgas distribution. The degree of inhomogeneous distribution was classified into 4 types (A–D). Type A: homogeneous (normal distribution as healthy control), type B: inhomogeneous (inhomogeneous distribution without hot spot and defect), type C: hot spot (inhomogeneous distribution with hot spots), type D: defect (inhomogeneous distribution with defect). And postoperative improvement were evaluated by this classifications.

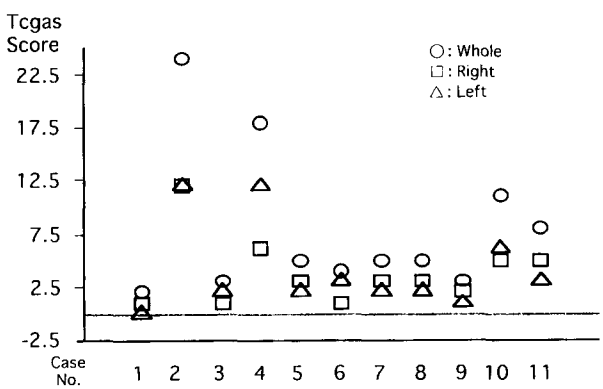


Fig. 4 In Tcgas scores post LVRS, improved in all patients (100%). In unilateral LVRS patients (Case nos. 9, 10: left LVRS, case no. 11: right LVRS), the contralateral lung also showed improvement.

%VC improved in 8 (72.7%), $FEV_{1.0}$ in 10 (90.9%), $FEV_{1.0}$% in 9 (81.8%) and %$FEV_{1.0}$ in 10 (90.9%) of 11 patients. Significant differences were found between preoperative and postoperative values except in %VC (Table 1).

Relationship between Tcgas Score for Whole Lung and Percentage Improvement in Pulmonary Function Tests

A correlation was found between the Tcgas score and the percentage improvement in $FEV_{1.0}$ ($p < 0.01$, $R = 0.9$), $FEV_{1.0}$% ($p < 0.05$, $R = 0.78$), and %$FEV_{1.0}$ ($p < 0.05$, R

= 0.73) among pulmonary function tests (Fig. 5).

DISCUSSION

Tcgas consisting of microparticles with a diameter of 5 nm is deposited in normal alveoli by inhalation and produces images very similar to ventilation images,[8,9] but it behaves like an aerosol in that an unequal accumulation of microparticles occurs in patients with obstructive pulmonary disease resulting in "hot spots," an excessive deposition of isotopes in the airways. Thus Tcgas does not produce accurate ventilation images in patients with

Table 2 Tcgas deposition patterns pre and post LVRS

Case No.	Tcgas Deposition Pattern											
	Right Lung						Left Lung					
	Upper		Middle		Lower		Upper		Middle		Lower	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	D	B	B	B–	A	B	B	B–	B	B+	A	A
2	C	A	D	B	D	B	C	A	D	A	C	B
3	C	C+	C	C+	C	C–	C	C+	C	C+	C	C–
4	C	B	C	B	C	B	D	B	D	B	D	B
5	C	C+	C	B	B	B	C	B	C	B	C	D
6	C	C+	C	C–	C	C+	D	D+	D	D+	C	C+
7	B	B–	C	B	C	B	C	C	C	C	C	B
8	C	C+	C	C+	C	C+	C	C	C	C+	C	C+
9	C	C+	C	C	C	C+	D	D	C	C+	C	C
10	D	C	C	C+	D	C	C	B	C	B	C	B
11	D	C	C	C+	D	C	C	C+	C	C+	C	C+

+: Improved, –: Deterioration

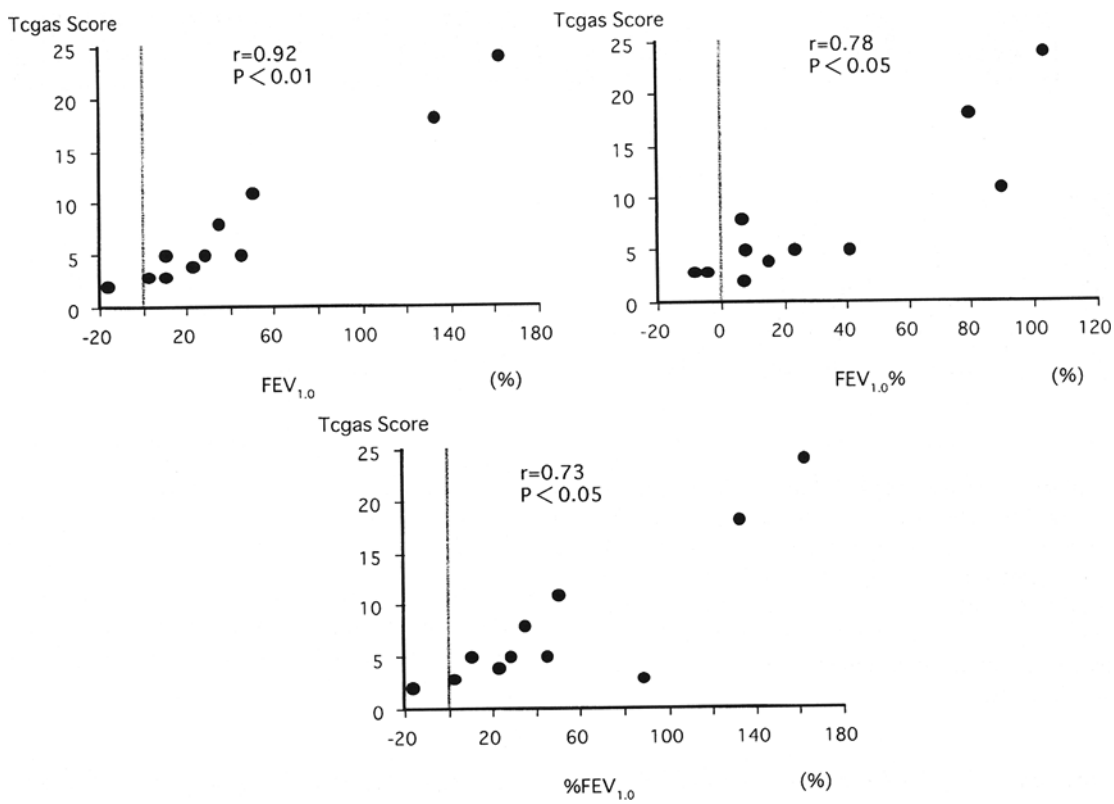


Fig. 5 The relationship between Tcgas score post LVRS and improvement percentage of pulmonary function tests can be seen in this figure. In each pulmonary function test, the higher the Tcgas score was the higher the improvement percentage was. The correlation between Tcgas score and improvement percentage of $FEV_{1.0}$, $FEV_{1.0}$%, %$FEV_{1.0}$ were statistically significant.

obstructive pulmonary disease,[10–12] yet it can be used to detect airway abnormalities in patients with obstructive pulmonary disease. Findings in SPECT with Tcgas correspond well to findings in CT. It has been reported that Tcgas SPECT is more sensitive in detecting regional pulmonary dysfunction than high resolution CT (HRCT) in pulmonary emphysema.[13] In the 2 cases presented, Tcgas SPECT images indeed revealed regional pulmonary dysfunction more sensitively than HRCT.

Chronic pulmonary emphysema is an irreversible disease characterized by alveolar destruction. The usefulness of surgery has recently been reevaluated for therapy of pulmonary emphysema, which was conservatively treated in the past. Due to recent advances in thoracoscopy, not only bullectomy but also LVRS is more frequently performed, and found to be effective in improving pulmonary function.[14–17] Thoracoscopic procedures remove emphysematous lesions and bullae which compress normal lung tissue. Chest CT and pulmonary function tests have been used to determine the extent of resection and to evaluate postoperative results.[18,19] It is possible to evaluate pulmonary structure in detail in pulmonary emphysema by HRCT, but HRCT images cannot reveal pulmonary function. Pulmonary function tests reveal whole pulmonary function, but they cannot reveal regional pulmonary function, whereas nuclear imaging can. Therefore nuclear imaging is useful for evaluating LVRS. Previously the usefulness of ventilation perfusion imaging with ^{133}Xe gas or ^{99m}Tc-MAA has been reported,[20,21] but only planar imaging is available in a usual ^{133}Xe gas ventilation study. Even if dynamic SPECT were used, 3-dimensional ventilation imaging could not be obtained. Perfusion studies are used for evaluating LVRS. But ventilation is important for evaluating pulmonary function. Ventilation defects lead to secondary changes in perfusion in chronic airway diseases. Moreover perfusion is underestimated in upper lung area because of gravity, so it is difficult to locate a target area in pulmonary emphysema with predominantly upper lung lesions. In this study, we studied the usefulness of Tcgas SPECT for 3-dimensional evaluation of pulmonary function post LVRS. Severe obstructive ventilatory impairment was found in most of our patients. Moreover, preoperative Tcgas distribution in SPECT images showed marked inhomogeneity and hot spots in all of our patients. We adopted the semiquantitative method of scoring which has been used in our institution for visual assessment of pulmonary Tcgas planar images. We previously reported that the classification of Tcgas planar image had a good correlation with $FEV_{1.0}$ and $\%FEV_{1.0}$, conventional indexes of obstructive pulmonary function impairment, in patients with various pulmonary diseases.[11,12] The present study confirmed that pulmonary distribution of Tcgas improved post LVRS in all patients. In those patients, pulmonary function and clinical symptoms also improved post surgery although the degree of improvement varied among cases. Tcgas distribution in the contralateral lung improved postoperatively in all 3 patients who underwent unilateral LVRS. It has been reported that the improvement in pulmonary function post LVRS is attributable to the improvement of lung elastic recoil. Recoil pressures may act in the direction of airway dilatation.[22] Thoracic movements, including diaphragmatic movements, play an important role in postoperative results. Improvement in the operated lung might facilitate diaphragmatic movements in the contralateral lung.[23] On the other hand, some pulmonary areas showed deterioration of Tcgas distribution post surgery in some cases. It has been suggested that regional deterioration of Tcgas distribution might occur even in cases where the overall pulmonary function improved post surgery. A correlation was found between the Tcgas score for the whole lung and $FEV_{1.0}$, $FEV_{1.0}\%$, $\%FEV_{1.0}$. It has been reported that $FEV_{1.0}$ is the best index of pulmonary function improvement post LVRS.[1,7] The present study suggested that the Tcgas score was another good index of pulmonary function. Three presented slices were chosen in this study. Because lung size varies, the number of slices also varies, making semiquantitative evaluation impossible. SPECT images are more useful than previously used planar images in evaluating 3-dimensional pulmonary function and in evaluating regional pulmonary function in upper, middle and lower fields. In the cases in this study, bilateral levels of the diaphragm were almost the same pre and post LVRS, so there was little influence as a result of the change in lung shape. Tcgas SPECT is expected to be useful for evaluating regional pulmonary function and postoperative results in patients with pulmonary emphysema.

CONCLUSION

Technegas inhalation SPECT is useful for evaluating regional pulmonary function pre and post thoracoscopic lung volume reduction surgery in patients with pulmonary emphysema.

REFERENCES

1. Cooper JD, Trulock EP, Triantafillou AN, Patterson GA, Pohl MS, Deloney PA, et al. Bilateral pneumectomy (volume reduction) for chronic obstructive pulmonary disease. *J Thorac Cardiovasc Surg* 109: 106–119, 1995.
2. Cooper JD, Patterson GA, Sundaresan RS, Trulock EP, Yusen RD, Pohl MS, et al. Results of 150 consecutive bilateral lung volume reduction procedures in patients with severe emphysema. *J Thorac Cardiovasc Surg* 112: 1319–1330, 1996.
3. Kotloff R, Tino D, Bravaria J, Palevsky HI, Hansen-Flaschen J, Wahl PM, et al. Bilateral lung volume reduction surgery for advanced emphysema. A comparison of median sternotomy and thoracoscopic approaches. *Chest* 110: 1399–1406, 1996.
4. Yusen RD, Lefrak SS, Trulock EP. Evaluation of patients

with emphysema for lung volume reduction surgery. *Semin Thorac Cardiovasc Surg* 8: 83–93, 1996.
5. Wakabayashi A, Brenner M, Kayaleh RA, Berns MW, Barker SJ, Rice SJ, et al. Thoracoscopic carbon dioxide laser treatment of bullous emphysema. *Lancet* 337: 881–883, 1991.
6. Kennan RJ, Landreneau RJ, Sciurba FC, Ferson PF, Holbelt JM, Brown ML, et al. Unilateral thoracoscopic surgical approach for diffuse emphysema. *J Thorac Cardiovasc Surg* 111: 308–316, 1996.
7. Mckenna RJ, Brenner M, Fischel RJ, Gelb AF. Should lung volume reduction for emphysema be unilateral or bilateral? *J Thorac Cardiovasc Surg* 112: 1331–1339, 1996.
8. Burch WM, Sullivan PJ, McLaren CJ. Technegas—a new ventilation agent for lung scanning. *Nucl Med Commun* 7: 865–871, 1986.
9. Isawa T, Teshima T, Anazawa Y, Miki M, Motomiya M. Technegas for inhalation lung imaging. *Nucl Med Commun* 12: 47–55, 1991.
10. James JM, Lloyd JJ, Leahy BC, Church S, Hardy CC, Shieods RA, et al. $^{99}Tc^{m}$-Technegas and krypton-81m ventilation scintigraphy: a comparison in known respiratory disease. *Br J Radiol* 65: 1075–1082, 1992.
11. Sasaki Y, Imai T, Kasuga H, Watanabe H, Ako H, Itou S, et al. Clinical evaluation of Tc-99m Technegas. *Jpn J Respir* 10: 821–829, 1991.
12. Imai T, Narita N. Diffuse panbronchiolitis and related diseases. *In*: Bahk YW, Kim EE, Isawa T, eds. Nuclear Imaging of the Chest. Heidelberg, Springer, pp. 131–156, 1998.
13. Satoh K, Tanabe M, Nakano S, Nishiyama Y, Takahashi K, Kobayashi T, et al. Comparison of ^{99m}Tc-Technegas scintigraphy and high resolution CT in pulmonary emphysema. *KAKU IGAKU (Jpn J Nucl Med)* 32: 487–494, 1995.
14. Eugene J, Ott RA, Gogia HS, Dos Santos C, Zeit R, Kayaleh RA. Video thoracic surgery for treatment of end-stage bullous emphysema and chronic obstructive pulmonary diseases. *Am Surg* 61: 934–936, 1995.
15. Wakabayashi A. Thoracoscopic laser pneumoplasty in the treatment of diffuse bullous emphysema. *Ann Thorac Surg* 60: 936–942, 1995.
16. Naunheim KS, Keller CA, Krucylak PE, Singh A, Ruppel G, Osterloh JF. Unilateral video-assisted thoracic surgical lung reduction. *Ann Thorac Surg* 61: 1092–1098, 1996.
17. Keller CA, Ruppel G, Hibbett A, Osterloh J, Naunheim KS. Thoracoscopic lung volume reduction surgery reduces dyspnea and improves exercise capacity in patients with pulmonary emphysema. *Am J Respir Crit Care Med* 156: 60–67, 1997.
18. Gierada DS, Slone RM, Bae KT, Yusen RD, Lefrak SS, Cooper JD. Pulmonary emphysema: Comparison of preoperative quantitative CT and physiologic index values with clinical outcome post lung-volume reduction surgery. *Radiology* 205: 235–242, 1997.
19. Yusen RD, Lefrak SS, Trulock FP. Evaluation and preoperative management of lung volume reduction surgery candidates. Surgical approaches to end-stage diseases: Lung transplantation and volume reduction. *In* Clinics in Chest Medicine, Vol. 18, Philadelphia, W.S. Saunders, pp. 199–224, 1997.
20. Suga K, Nishigauchi K, Shimizu K, Kawamura T, Matsunaga N, Sugi K, et al. Radionuclide imaging in emphysema after lung volume reduction surgery. *Clin Nucl Med* 22: 683–686, 1997.
21. Wang AC, Fischer KC, Slone RM, Gierada DS, Yusen RD, Lefrak SS, et al. Perfusion scintigraphy in the evaluation for lung volume reduction surgery: Correlation with clinical outcome. *Radiology* x205: 243–248, 1997.
22. Brantigan OC, Mueller E, Kress MB. A surgical approach to pulmonary emphysema. *Am Rev Respir Dis* 80: 194–202, 1959.
23. De Troyer A, Estenne M. Functional anatomy of the respiratory muscles. Respiratory muscles. *In*: Belman MJ, ed. Function in health and disease. Clinics in Chest Medicine Vol. 9, Philadelphia, W.S. Saunders, pp. 175–194, 1988.

Answer and comments:

Kan Takeda (Department of Radiology, Mie University School of Medicine)

The most interesting feature of this case is diffuse abdominal uptake of Ga-67. There is no abnormal uptake in the lung and mediastinum. According to Ammann et al.,[1] causes of diffuse gallium uptake in the abdomen are listed below.

Common:

1) Physiologic concentration in bowel loops

Less common:

1) Bacterial peritonitis
2) Diffuse inflammatory bowel disease
3) Generalized peritoneal or nodal metastases
4) Diffuse lymphoma
5) Retroperitoneal or abdominal wall inflammation
6) Spread of pancreatitis

Rare:

1) Tuberculous peritonitis
2) Starch peritonitis
3) Vasculitis
4) Mesenteric adenitis
5) Peritoneal mesothelioma

In the presented case, the chief complaint of the patient was vague abdominal fullness due to increase of ascites. Unlike acute bacterial peritonitis, chronic inflammatory processes such as tuberculous peritonitis may be insidious in onset. The gallium scan showed diffuse abdominal uptake, which could not be differentiated from diffuse neoplastic processes such as peritoneal metastases, disseminated lymphoma or mesothelioma. CT scans demonstrated massive ascites of high density. This finding suggests that the ascites is rich in protein and is often observed in tuberculous peritonitis. If there are some foci of tuberculosis in the lung or other sites, final diagnosis can be easily done.

Reference

1. Ammann W, Kassen BO. Diffuse abdominal gallium uptake. *Semin Nucl Med* 16: 214–215, 1986.