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Intrapulmonary distribution of ^{99m}Technetium labelled ultrafine carbon aerosol (Technegas) in severe airflow obstruction

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ABSTRACT: Technegas (TG), an ultrafine dispersion of carbon aggregates labelled with ^{99m}Technetium (^{99m}Tc), has been recently introduced for clinical imaging of lung ventilation. In 12 selected subjects with severe chronic airflow limitation (FEV_1 = 0.89±0.22; mean ±SD, *l*) we have studied the regional intrapulmonary distribution of TG and compared it quantitatively with that of ^{133}Xenon (^{133}Xe). A ^{133}Xe equilibration image was acquired for 10–15 s during a breathold at total lung capacity (TLC). Six subjects (Group 1) inspired 100 ml boli of TG or ^{133}Xe from functional residual capacity (FRC) and another 6 subjects (Group 2) inspired 1.0 *l* of labelled gas from FRC followed by air to TLC at a constant flow rate <0.5 $l \cdot s^{-1}$. Lung images were then acquired with the chest position rigorously controlled. From the equilibration image, upper, middle, lower, central and peripheral regions were defined. Relative regional fractional concentrations (RFC) were then calculated using the equilibration image to correct for ventilated lung volume. In addition, in four of the Group 2 subjects, each lung image was divided into multiple regions (12–17 per lung). The RFC were then calculated as above (RFC_M). The highest and lowest RFC were not significantly different between ^{133}Xe and TG in either Group 1 or Group 2 subjects. Similarly the RFC_M analysis showed no systematic difference between ^{133}Xe and TG. The ratio of peripheral to central RFC constitutes a penetration index which for TG was 0.99±0.23 that of ^{133}Xe. Our results indicate that even in the presence of severe airflow limitation the radiolabelled tracer TG mimics the regional distribution of a real gas.

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One of the principal limitations of radiolabelled aerosol techniques for the assessment of intrapulmonary distribution of inhaled gas has been the difference between particle deposition patterns and distributions of radioactive gases. When the particle size approximates to 1 μm in diameter, there is reasonable agreement between distributions of inhaled particles and radioactive gases in normal lungs. However, in patients with chronic airflow obstruction numerous studies have demonstrated predominant central deposition and patchy peripheral deposition [1–3].

In a companion paper [4] we report on the use of a new ventilation imaging agent called Technegas which consists of a dispersion of ^{99m}Technetium (^{99m}Tc) labelled aggregates of carbon with a particle diameter thought to be less than 0.01 μm [5]. We demonstrated that Technegas particles distribute in normal lungs in a manner similar to that of the radioactive gas ^{133}Xenon. This aerosol may contain the smallest radioactively labelled particle yet developed for the specific purpose of tracking the intrapulmonary distribution of inhaled gas in the lung. Since peripheral penetration of an inhaled radioaerosol is linked to particle size we hypothesized that, even in subjects with chronic airway obstruction, inhaled Technegas may penetrate to the alveolar regions of the lung as efficiently as a true gas. Therefore, in the present paper we compared the intrapulmonary distribution of ^{133}Xenon and Technegas in a group of patients with severe airway obstruction.

Materials and methods

Twelve male subjects with chronic obstructive airways disease were studied (table 1). Eleven of the 12 subjects had been or were current heavy smokers. All subjects showed a marked degree of airway obstruction and in 11 of the 12 subjects the diffusion capacity corrected for alveolar lung volume (Kco), was reduced consistent with a diagnosis of emphysema

Table 1. – Physical characteristics and pulmonary function of subjects

Subject No.	Age yrs	Sex	FEV_1 *l*		FVC *l*		TLC *l*		RV *l*		FRC *l*		Kco
			O	%P	O	%P	O	%P	O	%P	O	%P	%P
Group 1													
1	63	M	0.96	30	2.46	60	6.45	102	3.39	156	4.50	142	102
2	59	M	0.90	26	2.84	66	8.87	138	5.37	251	6.83	211	63
3	60	M	0.69	24	2.05	57	9.02	162	6.27	327	7.50	275	44
4	67	M	0.81	19	1.94	33	8.57	125	5.67	235	6.41	181	44
5	69	M	1.24	40	2.70	67	7.23	113	3.92	168	5.27	161	62
6	63	M	0.54	15	1.48	32	6.78	91	3.97	169	4.90	138	67
Mean	64		0.86	26	2.25	53	7.74	122	4.77	218	5.90	185	64
±SD	4		0.24	9	0.51	16	1.24	26	1.16	60	1.19	52	21
Group 2													
7	61	M	0.76	23	1.57	39	6.32	102	3.43	162	4.64	150	47
8	61	M	1.28	35	2.47	52	7.23	102	3.02	128	4.11	113	54
9	64	M	0.76	23	2.04	48	7.83	120	4.20	185	5.81	175	39
10	74	M	0.83	25	2.81	65	8.50	122	5.31	205	6.79	186	43
11	61	M	0.85	23	2.46	53	8.40	121	5.29	211	6.04	171	56
12	73	M	1.06	40	2.57	76	7.82	138	3.93	178	5.00	173	45
Mean	66		0.92	28	2.32	56	7.68	118	4.20	182	5.40	161	47
±SD	6		0.21	7	0.44	13	0.81	14	0.95	35	0.99	26	7

Group 1: 100 ml inspirations; Group 2: 1 *l* inspirations; O: observed; %P: % of predicted value; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity: TLC: total lung capacity; RV: residual volume; FRC: functional residual capacity; Kco: carbon monoxide transfer coefficient; M: male.

(table 1). The study protocol was approved by the Hospital Human Ethics and Radiation Safety Committees and informed consent was obtained from each patient.

In general the patients inhaled either 100 ml (Group 1) or 1 *l* (Group 2) of radiolabelled gas mixture from functional residual capacity (FRC), followed by air to total lung capacity (TLC). All counting was performed during breathholding at TLC. Each patient was seated in a chair in front of a large field of view gamma camera (Searle) connected to a DEC 11/34 on-line computer. The chair was fitted with a frame to control body position and incorporated a dual telescope system with cross-hairs focused on markers on the subject's chest. Immediately prior to each counting period chest position in relation to the gamma camera was checked using the telescope system.

Subjects breathed through a mouthpiece connected to a 3-way tap allowing them to breathe either room air or the gas mixtures containing ^{133}Xenon (^{133}Xe) or Technegas. For Group 1 subjects the tracers were contained in a small rubber bag attached to the 3-way tap. For Group 2 subjects, the tracers were contained in a 4 *l* anaesthetic bag, enclosed within a glass bottle, and connected to the 3-way tap by rubber tubing. The 3-way tap also allowed the subject to be connected to a lead shielded spirometer (XDS2, Nuclear Associates) containing the equilibration mixture (18.5 MBq·l^{-1} of ^{133}Xe in air). Inspiratory flow in Group 1 subjects was measured by a respiratory flow meter (Okada) attached to a non re-breathing Hans Rudolph valve. Since this was positioned distal to the small rubber bag, only flow after inspiration of the 100 ml tracer could be measured. For Group 2 subjects the flow meter was positioned at the outlet port of the glass bottle containing the rubber bag and thus could only measure flow during inspiration of the tracer (1 *l*). The flow signal was integrated to give inspiratory volume. Both flow and volume signals were plotted against time on a Hewlett Packard x-y plotter. The inspiratory flow signal was also displayed to the subject on a Tektronics storage oscilloscope.

Protocol

Group 1. A 100 ml bolus of ^{133}Xe (18.5 MBq) was injected into the small rubber bag. After a period of quiet breathing each subject held his breath at end expiration while the three-way tap was turned into the small rubber bag. The subject then slowly inhaled the tracer, and once

the bag was empty the three-way tap was turned to room air, allowing the subject to continue inspiring to TLC at a controlled flow rate of <0.5 $l \cdot s^{-1}$. At TLC, the mouthpiece was occluded and the subject relaxed (relaxed TLC). After verifying correct chest position, counts were accumulated by the gamma camera over a 10–15 s period. The subject then exhaled and hyperventilated with room air to clear the radioactive gas from the lung. Exhaled gas was collected by a gas scavenging system and pumped out of the laboratory.

Following 2–3 Xenon bolus inhalations, each subject rebreathed from the spirometer containing ^{133}Xe until equilibration, as judged by a stable count rate. Subjects then inhaled to TLC and relaxed against the occluded mouthpiece. Following checking of chest position, counts were recorded for 10–15 s. The subject was then connected to room air and hyperventilated to washout the ^{133}Xe.

Technegas inhalations were performed after the ^{133}Xe study was completed. In this phase, 100 ml volumes of freshly generated Technegas containing progressively 2.8–13.9 MBq of ^{99m}Tc were placed in the rubber bag and the subjects performed inhalation manoeuvres identical to those using ^{133}Xenon. Since Technegas particles are deposited and not exhaled, it was necessary to correct repeated Technegas counts by subtracting those from previously deposited boli. To increase the accuracy of the subtraction procedure we progressively increased the amount of radioactivity administered in successive Technegas inspirations, so that counts in the 2nd and 3rd inhaled Technegas boli were approximately 3 and 5 times those inhaled in the first bolus, respectively. Furthermore, in all subjects double counting periods were used to maximize count rates, *i.e.* following the counting period the subject exhaled to FRC and then reinspired air to TLC at which point cumulative counting continued.

Prior to inspiration of each ^{133}Xe bolus and the first Technegas bolus, background counts were recorded at relaxed TLC.

Group 2. The protocol was identical to the above except that the subjects slowly inspired 1 l of ^{133}Xe (18.5 MBq) or freshly generated Technegas (2.8–13.9 MBq) followed by room air to TLC.

Data analysis

Analysis was similar for both groups, except where otherwise stated. The ^{133}Xe equilibration image for each subject was divided into 3 regions of equal size arranged vertically from superior to inferior over each lung. For each subject these same regions were then used in the analysis of the topographical distribution of inhaled ^{133}Xe and Technegas boli.

Regional accumulated counts for both ^{133}Xe equilibration image and all bolus inhalation images were normalized for the total counts in all 6 lung regions. To compensate for the different volume of lung within each region as well as for differences in chest wall absorption between regions, the fractional count rates obtained after bolus inhalation were normalized by those obtained after the ^{133}Xe equilibration. This allowed the calculation of the relative regional fractional concentration (RFC) of ^{133}Xe and Technegas in each of the 3 regions of each lung. Because of the better counting statistics achieved after 1 l as compared to 100 ml inspirations we performed a more detailed analysis of the topographical distributions of both ^{133}Xe and Technegas in 4 of the 6 subjects from Group 2 (nos 7, 8, 9, 12, table 1). A data analysis rectangle was set up, fitting as closely as possible to the image contour of each equilibration lung image. Each lung image was then divided into approximately 32 pixel rectangular areas using a grid pattern. Any areas containing the equilibration image contour were rejected from further analysis. In each of the 4 subjects we obtained 12–17 regions per lung. Relative fractional concentrations of each region for both Technegas and ^{133}Xe were then calculated as described above.

Table 2. – PIF, MIF and IV in 6 subjects of Group 1 and 6 subjects of Group 2

	Group 1		Group 2	
	^{133}Xe	Technegas	^{133}Xe	Technegas
PIF $l \cdot s^{-1}$	0.59±0.09	0.62±0.15	0.41±0.03	0.36±0.04
MIF $l \cdot s^{-1}$	0.20±0.06	0.23±0.09	0.26±0.02	0.25±0.04
IV l	1.50±0.48	1.53±0.53	NM	NM

Mean (±SD) peak inspiratory flow (PIF), mean inspiratory flow (MIF) and inspired volume of room air (IV) in 6 subjects following inspiration of 100 ml boli ^{133}Xenon (^{133}Xe) or Technegas in air (Group 1) and PIF and MIF in 6 subjects during inspiration of 1 l volumes of ^{133}Xenon or Technegas in air (Group 2). NM: not measured.

The relative penetration of Technegas and ^{133}Xe into the lung periphery was calculated using a modification of the method described by DOLOVICH *et al.* [6]. We identified peripheral and central areas of each lung from the Xenon equilibration image and then used these to measure the ratio of peripheral to central counts, normalized for lung volume, for each tracer gas (penetration index). The peripheral and central areas were constructed such that they occupied approximately 50% and 25% of the area of each lung, as seen on the equilibration image. The penetration index for Technegas was then divided by the corresponding penetration index for ^{133}Xe to give a relative penetration index for each lung in each subject.

Results

In Group 1 subjects there was no significant difference in inspiratory capacity, peak inspiratory flow (PIF) and mean inspiratory flow (MIF) between inspirations following ^{133}Xe or Technegas bolus inhalation ($p>0.3$, table 2). The ranges of PIF and MIF were

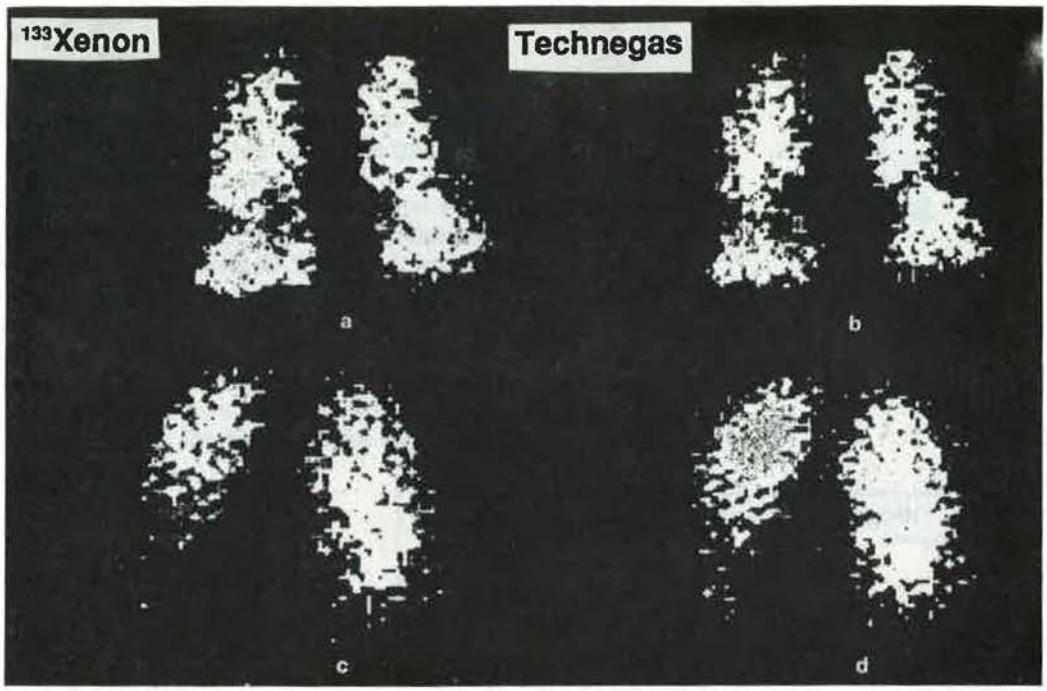

Fig. 1. – Posterior-anterior images of subjects 7 and 12 (a and b, c and d, respectively) after inhaling 1 *l* volumes of ^{133}Xenon (a, c) and Technegas (b, d). Note the similarity between ^{133}Xenon and Technegas images. Since both ^{133}Xenon and Technegas images were obtained from counting periods of 10–15 s they are inferior to images obtained under routine diagnositc imaging conditions where longer counting periods are routinely used.

0.42–0.78 $l \cdot s^{-1}$ and 0.13–0.28 $l \cdot s^{-1}$, respectively. Similarly, in Group 2 subjects PIF and MIF measured during 1 *l* inspirations were not significantly different between ^{133}Xe and Technegas manoeuvres (p>0.1, table 2). In this group the ranges of PIF and MIF were 0.28–0.44 $l \cdot s^{-1}$ and 0.21–0.30 $l \cdot s^{-1}$, respectively.

Qualitative comparison

Technegas images for both 100 ml and 1 litre inspirations were found to be qualitatively similar to those obtained with ^{133}Xe (fig. 1). In no subject was there evidence of tracheal or central airway deposition on the Technegas images. In one subject only (subject no. 1) we observed a minute localized 'hot spot' of Technegas not apparent on the corresponding ^{133}Xe images.

Topographical distribution of inhaled tracers

The relative regional fractional concentration (RFC) of ^{133}Xe and Technegas for both 100 ml and 1 *l* inspirations of each subject's 6 lung regions are shown on an identity plot in figure 2. For both manoeuvres there were significant linear correlations between ^{133}Xe and Technegas RFC (p<0.001). For 100 ml inspirations, the y intercept and regression coefficient were 0.17 and 1.17, respectively. For 1 *l* inspirations the corresponding values were -0.05 and 1.06, respectively. This suggests that 100 ml inspirations depart more from a perfect relationship than is the case for 1 *l* inspirations. Figure 3 shows for each subject the region with the highest and lowest relative fractional concentration of ^{133}Xe and corresponding values for Technegas (RFC_H, RFC_L, respectively). For 1 *l* inspirations, there was no significant difference between the RFC_H or RFC_L for either of the two tracers (p>0.6, p>0.5, respectively). For 100 ml inspirations, there was a trend for the RFC_H and RFC_L of Technegas to be greater and smaller, respectively, when compared with the corresponding values for ^{133}Xe. However, these differences were not statistically significant (p>0.1).

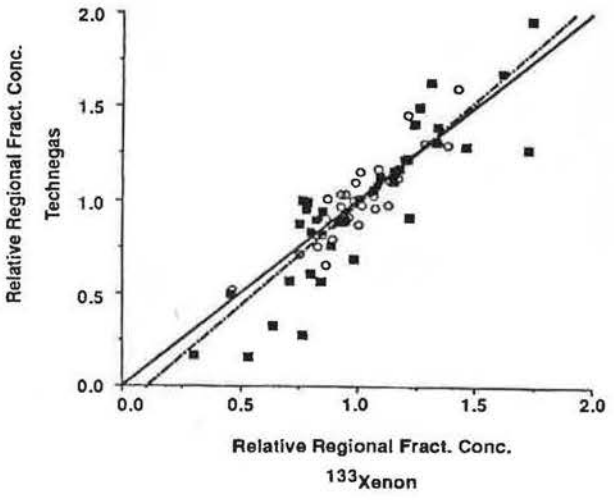

Fig. 2. – Identity plot of the relative regional fractional concentrations of Technegas and ^{133}Xenon following 100 ml (■) and 1 *l* (○) inspirations for each subject's 6 lung regions. Regression line for the combined data (dashed) is shown (r=0.884).

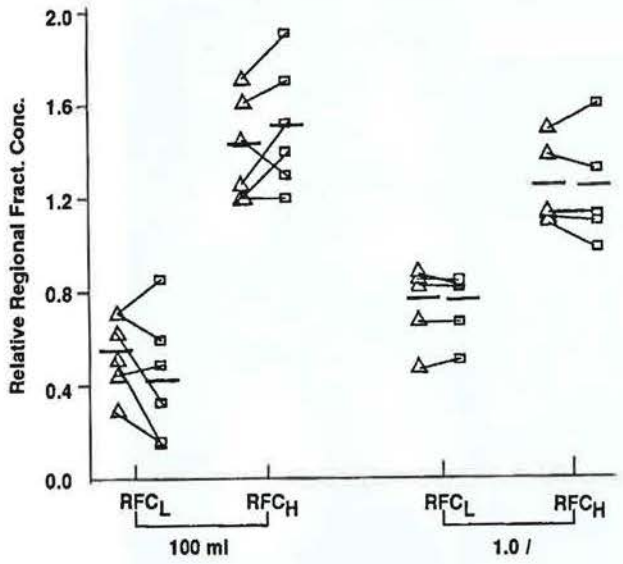

Fig. 3. – Highest and lowest relative regional fractional concentrations (RFC_H and RFC_L, respectively) for each subject's 6 lung regions for both ^{133}Xenon (^{133}Xe) and Technegas. ^{133}Xe and corresponding Technegas values for each subject are connected by straight lines. Group mean values are identified by the thick horizontal lines. There were no significant differences between ^{133}Xe and Technegas RFC_H and RFC_L for either 100 ml or 1 *l* inspirations. Δ : ^{133}Xe; □ : Technegas.

Figure 4 shows individual identity plots for the 4 subjects from Group 2 in whom multiple RFC for ^{133}Xe and Technegas were calculated in each lung. This analysis generally provided a wider range of RFC compared with that limited to the 6 larger lung regions (fig. 2). In none of the 4 subjects, however, is there a systematic difference between the two tracers.

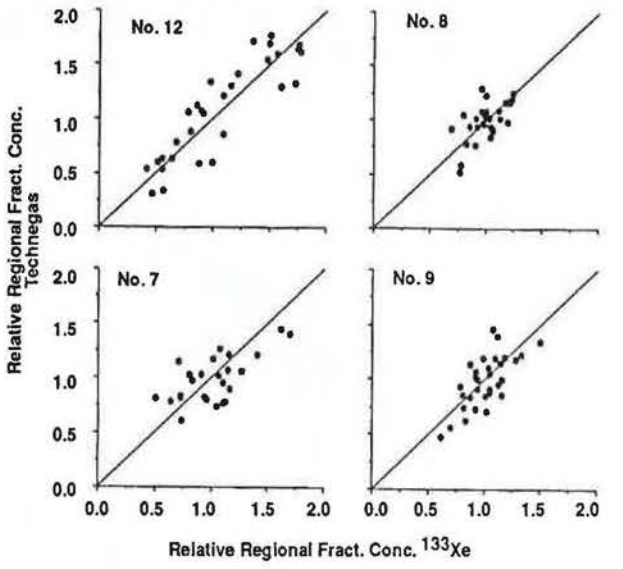

Fig. 4. – Identity plots of multiple relative regional fractional concentrations for both tracers ^{133}Xenon (^{133}Xe) and Technegas obtained from 4 of the subjects who inspired 1 *l* volumes of both tracers from functional residual capacity. For each subject there are 12–17 regions per lung.

Peripheral penetration

Figure 5 plots the mean penetration index for ^{133}Xe (PIXe) against the corresponding penetration index for Technegas (PITG) for each lung of each of the 12 subjects. While there is considerable intra- and interindividual variability for both 100 ml and 1 *l* inspirations, the data points are reasonably distributed around the line of identity with a significant correlation ($p<0.001$). The mean relative penetration index (RPI) (*i.e.* PITG/PIXe) did not significantly differ from 1.0 either for 100 ml inspirations (0.99 ± 0.23; $p>0.7$), or for 1 *l* inspirations (1.025 ± 0.23; $p>0.4$). Furthermore, there were no significant differences in the RPI between left and right lung for either 100 ml or 1 *l* inspirations ($p>0.6$).

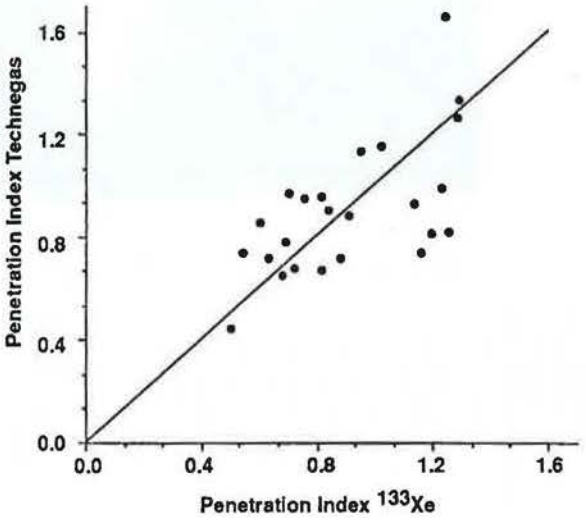

Fig. 5. – Penetration index of the tracer Technegas plotted against the corresponding penetration index for ^{133}Xenon (^{133}Xe) for each subject's two lungs. The data points are distributed around the line of identity.

Discussion

The principal finding of this study is that in subjects with severe airways obstruction the topographical intrapulmonary distribution of the ultrafine aerosol Technegas does not differ from that of ^{133}Xe when inhaled either as 100 ml or 1 *l* volumes at low flow rates from FRC.

To permit comparisons of our findings in severe airways obstruction with those in normal subjects [4] our first 6 subjects inspired 100 ml volumes of both Technegas and ^{133}Xe from FRC as did the normal subjects. The second group of 6 subjects inspired 1 *l* volumes of both tracers, allowing us to more closely approximate the clinical administration of Technegas, and to examine changes in topographical distribution with inspired volume. The inspiration of 1 *l* volumes also resulted in higher count rates, permitting a more detailed analysis of both Technegas and ^{133}Xe images (fig. 4). Whereas the manoeuvres were not strictly comparable because of the different subject populations, the two

groups were closely matched both in the degree of impairment of pulmonary function and inspiratory flows during the study (tables 1 and 2).

Topographical distribution of ventilation in the presence of severe airways obstruction is probably largely determined by inequalities in time constants and airway opening pressures among lung units. Inspiration of 100 ml, as opposed to 1 *l* volumes of tracer gases should be more sensitive in detecting inequalities of ventilation resulting from either of these two mechanisms. Indeed, this is consistent with our current findings in which 100 ml inspirations of ^{133}Xe show a wider distribution of regional specific ventilations than that for 1 *l* inspirations (figs 2 and 3). In both subject groups the magnitude and topographical nature of the distribution of regional specific ventilations did not differ either for ^{133}Xe or for Technegas. The trend towards a greater maldistribution of Technegas compared with ^{133}Xe for the 100 ml manoeuvre was not evident for the 1 *l* manoeuvre (figs 2 and 3). Even when the lung images of the 1 *l* manoeuvres were divided into much smaller topographical regions, thereby increasing the range of specific ventilations, no consistent difference between the distribution for the 2 tracers was evident (fig. 4). Differences in the specific imaging characteristics of the two isotope labels (^{99m}Tc and ^{133}Xe) might well account for the trend towards greater maldistribution for Technegas compared with ^{133}Xe during the 100 ml inspirations. In the detection system used in the current study the attenuation characteristics of ^{133}Xe were greater relative to ^{99m}Tc [4]. Furthermore, systemic absorption of ^{133}Xe with subsequent chest wall uptake will potentially introduce an artefact in comparison with Technegas which remains within the lung. Both these factors would tend to result in ^{133}Xe underestimating the topographical distribution of ventilation compared with Technegas.

For both 100 ml and 1 *l* inspirations there was no difference in the penetration index between the two tracers. The considerable inter- and intra-subject variability in the individual tracer penetration indexes (fig. 5) as well as in the corresponding relative penetration indexes (see Results) is consistent with previous studies comparing radioactive gases with larger sized radiolabelled aerosols both in health and disease [1–3, 7, 8]. As pointed out by NEWMAN *et al.* [9], the penetration index is a relatively crude method for quantifying preferential deposition patterns of aerosols compared with real gases. The topographical regions chosen to represent 'central' and 'peripheral' lung regions may only partly reflect actual lung anatomy, particularly in patients with severe underlying disease as in our study. In contrast to our study in normal subjects [4] we were unable to demonstrate a greater relative peripheral penetration for Technegas to the left lung compared with the right lung. Whereas this may have been a consequence of the greater variability evident in the current study, it might also reflect a reduction in the effect of cardiogenic mixing between dead space and alveoli for ^{133}Xe due to the the poorer transmission of cardiogenic impulses in the obstructed lung [10].

The intrapulmonary deposition of inhaled particles is determined by inertial impaction, gravitational settling and Brownian diffusion [11]. The principal factor determining particle deposition, the mechanism responsible and the site within the lung, is the particle size. Both the probability of deposition by inertial impaction and gravitational settling is proportional to the square of the particle diameter [11]. In normal lungs there is minimal deposition of particles 0.5 μm in diameter [12] as these are sufficiently small to be relatively independent of inertial impaction and gravitational settling but still sufficiently large to exhibit a low probability of deposition by Brownian motion. Hence, such particles effectively trace the convective distribution of gas flow in normal lungs [13].

The probability of inertial impaction in an airway is also proportional to particle velocity and is greater in turbulent than laminar flow. Hence the preferential site for particle deposition by inertial impaction is in the central airways where the overall cross-sectional area is relatively small and convective flow is turbulent. In contrast, deposition of particles less than 0.5 μm in diameter by the process of Brownian motion takes place in the lung periphery and increases progressively with decreasing particle size [14, 15]. Theoretically, however, inhaled particles of extremely small size may actually preferentially deposit on conducting airways as a consequence of their high diffusivity [16].

The mode of inspiration, as well as alterations in airway dynamics and lung geometry may modify particle deposition. Thus increased flow rates or airway narrowing will increase the probability of inertial impaction for a given particle size. Whereas aerosol images using particles with diameters less than 2 μm do not show preferential central deposition compared with true gases in normal subjects [1–3, 7, 8, 17] in patients with severe airway obstruction aerosols of particles as small as 0.12 μm have consistently shown preferential central deposition [1–3, 7, 8]. Presumably this is a consequence of marked reductions in the diameters of proximal airways in such subjects, increasing the inertial impaction of even submicronic particles. In addition, in most of these studies there is an increased patchiness of aerosol distribution extending out into the lung periphery. Such patterns have been attributed to localized impaction of aerosol particles in relatively peripheral airways which are grossly narrowed and/or distorted. Alternatively, the relatively greater peripheral maldistribution of aerosols may reflect the inability of those particles which actually do reach the peripheral lung regions to distribute *via* collateral channels. Presumably these relatively large particles deposit at the opening or within such channels. Our inability to distinguish between the topographical distribution of Technegas and ^{133}Xe in subjects with severe airflow obstruction is in marked contrast to the above mentioned studies [1, 2, 7, 8].

There is no direct physico-chemical evidence as to the specific size or structure of the Technegas radiolabelled particles. However, the observation that Technegas mimics real gas distribution so effectively in patients with severe airways obstruction suggests that the

particles are of a sufficiently small size to exhibit minimal inertial impaction even in the presence of severe airway narrowing and distortion. Moreover, the small particle size promotes peripheral deposition by the process of Brownian motion akin to the diffusive mixing of inspired and resident gas.

Our current results indicate that the imaging agent Technegas, when administered in the clinical setting, satisfactorily traces gas flow distribution even in patients with severe airflow obstruction. In addition, the unique characteristics of Technegas make it a potential research tool in the areas of intrapulmonary gas mixing, particle deposition and the estimation of respiratory air-space dimensions. However, application of this agent in these research fields awaits a more detailed description of its physical chemistry and the accurate determination of its particle size.

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Distribution intrapulmonaire du Technegas (aérosol ultrafin de carbone marqué au technetium^{99m}) dans les obstructions sévères des voies aériennes. A.B.H. Crawford, A. Davison, T.C. Amis, L.A. Engel.

RÉSUMÉ: Technegas (TG), dispersion ultrafine d'aggrégats de carbone marqués au ^{99m}Tc a été récemment introduit dans l'imagerie clinique de la ventilation pulmonaire. Chez 12 sujets sélectionnés atteints d'une limitation chronique sévère des débits aériens (FEV_1 = 0.89±0.22 (±SD)), nous avons étudié la distribution régionale intrapulmonaire de TG et l'avons comparée quantitativement avec celle du ^{133}Xe. Une image d'équilibration du ^{133}Xe a été enregistrée pendant 10–15 secondes, pendant une pause à la CPT. Six sujets (groupe 1) ont inspiré des boli de 100 ml, soit de TG, soit de ^{133}Xe, à partir de CRF, et six autres (groupe 2) ont inspiré 1.0 *l* de gaz marqué, à partir de CRF, suivi d'air jusqu'à CPT, à un débit constant <0.5 $l \cdot s^{-1}$. Les images pulmonaires ont été enregistrées en contrôlant rigoureusement la position du thorax. L'on a défini les régions supérieure, moyenne, inférieure, centrale et périphérique à partir de l'image d'équilibration. Les concentrations fractionnelles régionales relatives (RFC) ont été calculées en utilisant l'image d'équilibration pour corriger en fonction du volume pulmonaire ventilé. En outre, chez 4 sujets du groupe 2, chaque image pulmonaire a été divisée en régions multiples (12–17 par poumon). RFC a ensuite été calculée comme plus haut (RFC_M). Les valeurs les plus hautes et les plus basses de RFC ne sont pas différentes après ^{133}Xe ou TG, que ce soit dans le groupe 1 ou le groupe 2. De même, l'analyse de FRC_M ne montre pas de différence systématique entre ^{133}Xe et TG. Le rapport RFC periphery/FRC central est index de pénétration dont la valeur avec TG est 0.99±0.23 fois celle obtenue avec ^{133}Xe. Nos résultats indiquent que même en présence d'une limitation sévère des débits aériens, le traceur radiomarqué TG mime la distribution régionale d'un vrai gaz. *Eur Respir J., 1990, 3, 686–692.*