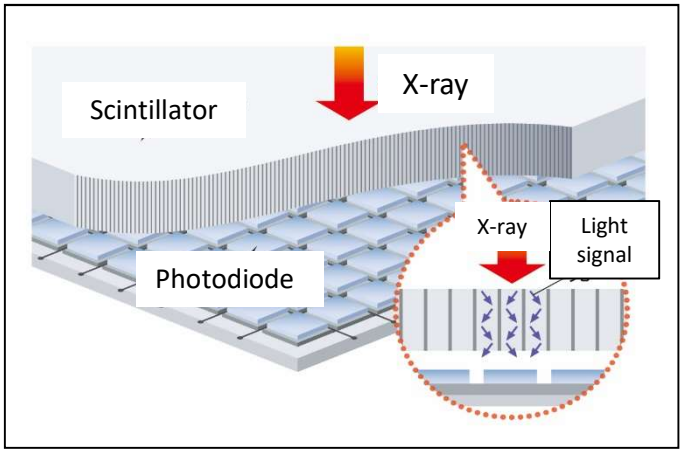
Evaluation of pulmonary function using dynamic chest radiographs: the change rate in lung area due to respiratory motion reflects air trapping in COPD.

1. Dept. of Respiratory Medicine, Kanazawa University.
2. Dept. of Thoracic, Cardiovascular and General Surgery, Kanazawa University.
3. College of Medical, Pharmaceutical & Health Sciences, Kanazawa University.

Noriyuki Ohkura[1], Kazuo Kasahara[1], Satoshi Watanabe[1], Miki Abo[1],
Johsuke Hara[1], Takashi Sone[1], Hideharu Kimura[1],
Masaya Tamura[2], Isao Matsumoto[2], Sanada Shigeru[3], Rie Tanaka[3]

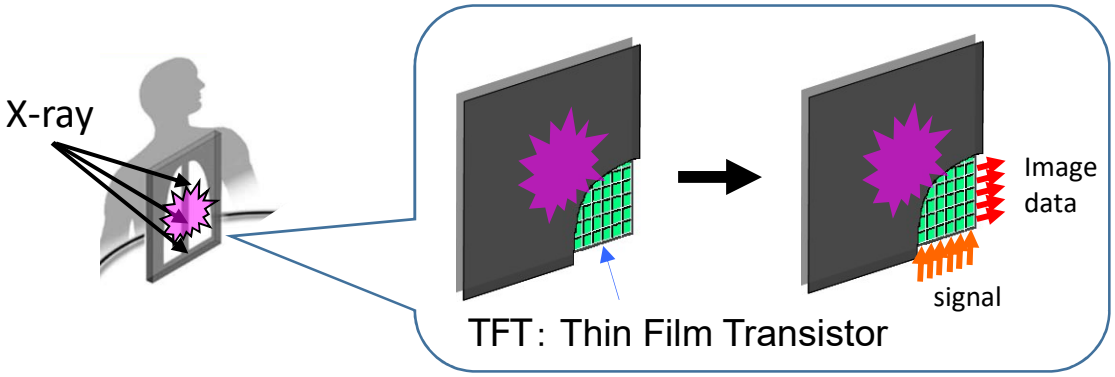
[BACKGROUND] Dynamic hyperinflation is one of the characteristics of COPD. The aim of this study is to investigate the dynamic chest X-ray as an alternative examination for evaluation of pulmonary function.
[METHODS] 121 patients (36 patients with lung cancer with normal pulmonary function, 56 patients with COPD, 24 patients with interstitial lung disease, 5 others) were recruited from our hospital.
The lung area was calculated by the data obtained from dynamic chest radiographs. Dynamic chest radiographs systems (prototype) were provided by Konica Minolta, Inc., Tokyo, Japan.
We investigated the relationship among the lung area, change rate in lung area due to respiratory motion (deep inspiratory and expiratory phase) and the data (e.g. VC, FVC, FEV_1, FRC, RV, TLC) obtained from conventional pulmonary function tests such as spirometry and lung volumes (Helium dilution method).
[RESULTS] The value of lung area at deep inspiratory phase was strongly associated with VC, FRC, RV and TLC (VC vs lung area: $r = 0.72$, FRC vs lung area: $r = 0.86$, RV vs lung area: $r = 0.69$, TLC vs lung area: $r = 0.82$, $p < 0.05$).
The change rate in lung area due to respiratory motion was negatively associated with RV/TLC ratio ($r = -0.40$, $p < 0.05$).
The subjects with COPD showed significant decrease in the change rate of lung area due to respiratory motion in a FEV_1- dependent manner. (Kruskal-Wallis test, $p < 0.05$).
[CONCLUSION]
The dynamic chest X-ray is an alternative indicator for air trapping in COPD.

Digital Radiography (DR)



Scintillator: X-ray to light signal.
Photodiode: light signal to electric charge

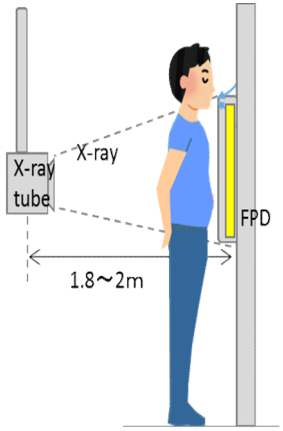
→ Accumulation of image data on TFT



- DR provides a lot of image data with a great X-ray dose efficacy.
- The aim of this project is to Investigate the clinical utility of dynamic chest X-ray with DR.

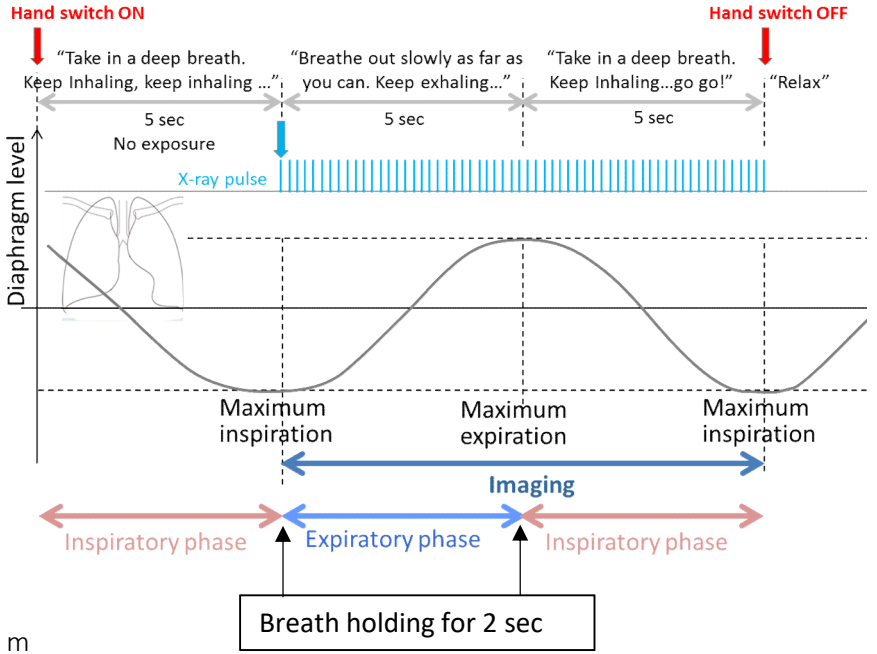
Method

- Except for breathing manner and X-ray pulse, imaging is performed in the same way of the conventional chest method.
- The radiation dose (for 20 sec) is 0.23 mSv.



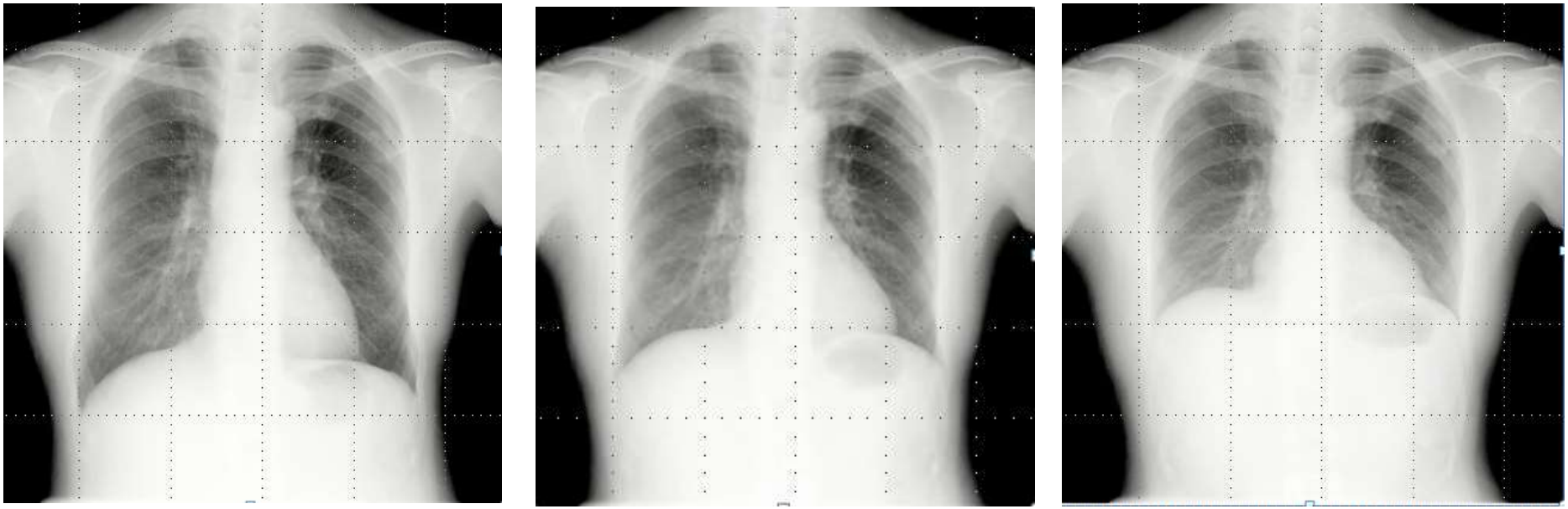
Standing position
PA direction.

@100 kV, 50 mA, 4.0 ms, 15 fps, SID = 2.0 m



Change rate in lung area due to respiratory motion

Maximum inspiration ⟷ Maximum expiration



(A) (B)

Change rate in lung area = (A – B)/ A

Characteristics of subjects

	Mean ± SD
Age (years)	68.5 ± 9.3
M/F	80/41
Height (cm)	161.6 ± 8.7
Body weight (kg)	58.8 ±10.2
VC (%pred)	105.4 ± 24.5
FEV1(%pred)	100.2 ± 28.4
FEV1/FVC ratio (%)	70.0 ± 13.1
FRC (%pred)	98.4 ± 22.2
RV (%pred)	104.2 ± 21.0
TLC (%pred)	100.4 ± 21.1
RV/TLC ratio (%)	36.8 ± 7.3

(n = 121)

(36 patients with lung cancer with normal pulmonary function, 56 patients with COPD, 24 patients with interstitial lung disease, 5 others)
Lung volumes were measured with Helium dilution method.

Association between lung area and pulmonary function

	Lung area	
	r	p
VC	0.72	< 0.05
%VC	0.53	< 0.05
FEV_1	0.53	< 0.05
$\%FEV_1$	0.11	0.21
FEV_1/FVC	-0.33	< 0.05
MMF	0.004	0.96
%MMF	-0.12	0.18
FRC	0.86	< 0.05
%FRC	0.60	< 0.05
RV	0.69	< 0.05
%RV	0.51	< 0.05
TLC	0.82	< 0.05
%TLC	0.53	< 0.05
RV/TLC	0.001	0.99
%RV/TLC	0.18	<0.05

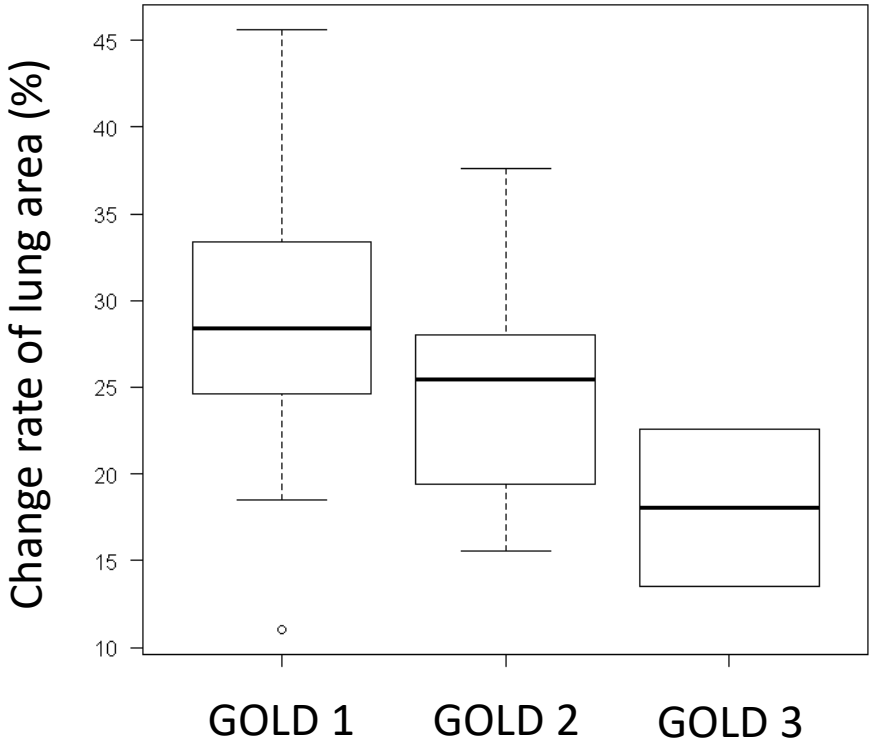
Association between pulmonary function and the change rate in lung area due to respiratory motion

	%change	
	r	p
VC	0.21	<0.05
FEV_1	0.31	<0.05
FEV_1/FVC	0.05	0.61
MMF	0.15	0.11
FRC	-0.10	0.28
RV	-0.18	<0.05
RV/TLC	-0.40	<0.05
TLC	0.07	0.46

Characteristics of subjects with COPD

	(n = 56)
Age (years)	71.7 ± 7.9
M/F	39/17
Height (cm)	161.1 ± 8.1
BW (kg)	59.4 ± 11.1
VC (%pred.)	114.0 ±17.9
FEV_1 (%pred.)	97.6 ± 29.2
FEV_1/FVC	58.9 ± 9.2
FRC (%pred.)	106.6 ± 16.1
RV (%pred.)	116.3 ± 20.6
TLC (%pred.)	110.3 ± 14.1
RV/TLC	38.1 ± 5.5

Change rate of lung area in COPD decreased in a FEV_1-dependent manner.



n = 56,
Kruskal-Wallis
test $p < 0.05$

GOLD 1 (mild) : $\%FEV_1 \geqq 80\%$ (n = 42)
GOLD 2 (moderate): $50 \leqq \%FEV_1 < 80\%$ (n = 12)
GOLD 3 (severe): $30 \leqq \%FEV_1 < 50\%$ (n = 2)

RESULTS

- Lung area at deep inspiratory phase was strongly associated with VC, FRC and TLC.

- Change rate in lung area due to respiratory motion was negatively associated with RV/TLC.

- COPD patients showed significant decrease in the change rate of lung area due to respiratory motion in a FEV_1- dependent manner.

CONCLUSION

The dynamic chest X-ray is an alternative indicator for air trapping in COPD.

Acknowledgments

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- Device used in this study was provided by Konica Minolta, Inc., Tokyo, Japan.