# A New Technology: The Dynamic Image of a Forced Breath Compared to a Tidal Breath Uncovers a Physiological Phenomenon in COPD.

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## BACKGROUND

- The respiratory cycle is being investigated using a new technology, the dynamic chest x-ray (DCXR).
- This modality provides sequential chest radiographs with high temporal resolution (7.5-30 frames/s) during the respiratory cycle with a low radiation dose (DCXR average < 0.04 mSV compared with static CXR 0.02 mSV) [1, 2.]
- The DCXR provides a visual display of the moving interactions of lung, muscle, bone, heart and nerve, not captured by pulmonary function testing (PFT). Previously, the action of respiration could only be radiologically assessed by fluoroscopy, which involves higher levels of radiation exposure.
- In COPD, diaphragm motion is a key element readily visible in the DCXR. We explored the relationship of diaphragm excursion in COPD patients during forced and tidal breathing. We hypothesize that the ratio of tidal diaphragm excursion to forced diaphragm excursion (TB/FB) would be related to the severity of COPD.

## METHODS

•PFTs and DCXR images from Fukujuji Hospital, Japan were provided and reviewed.

•During dynamic imaging, patients were asked to take 2 tidal breaths followed by a forced inspiration and expiration. A total of 70 patients' data was reviewed, 38 with COPD (4 female & 32 male), 32 normal (20 female & 12 male); 2 subjects were excluded given inadequate data.

| COPD Severity/FEV1 % Predicted | COPD Patients |
|---|---|
| Gold 1 (≥80) | 0 |
| Gold 2(50-80) | 14 |
| Gold 3 (30-50) | 21 |
| Gold 4 (<30) | 1 |

COPD mean age: 71
Control Group mean age: 55

- Vertical right hemidiaphragm measurements were obtained during tidal breath (TB) and forced breath (FB) on inspiration and expiration.
- A ratio of diaphragmatic excursion TB/FB ($DE_{TB/FB}$) was calculated. The relationship between $DE_{TB/FB}$ to COPD severity, using each patient's predicted $FEV_1$% were explored.
- Results were analyzed using multivariate linear regressions using STATA15 software.

## Figures

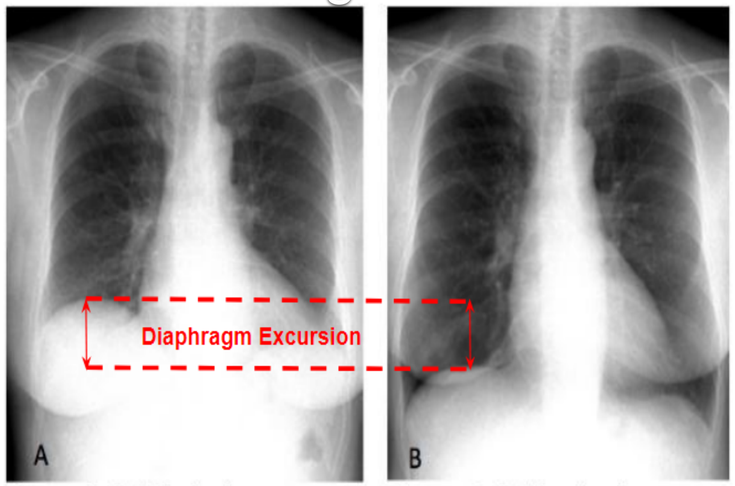


**Image A**- Full Expiration **Image B**- Full Inspiration

**Figure.** Sequential radiographs with dynamic X-ray in a normal subject.

Table 1.
$FEV_1$%: percentage of the forced expiratory volume for one second. $DE_{TB/FB}$: ratio of diaphragm excursion during tidal breathing to forced breathing. 95%CI: 95% confidence interval

| Variable | $DE_{TB/FB}$ | P value | 95%CI |
|---|---|---|---|
| COPD | 0.053 | 0.039 | 0.0027-0.1038 |
| $FEV_1$ | 0.0028 | 0.008 | -0.0048- -0.0008 |

## RESULTS

- In COPD, tidal diaphragm excursion to forced diaphragm excursion ($DE_{TB/FB}$) was significantly related to the $FEV_1$%.
- Having COPD increases $DE_{TB/FB}$ by 0.053 when compared to normals, even after adjusting for gender, age, tidal breathing and forced breathing (p=0.039; 95% CI 0.0027-0.1038).
- It was also noted that for every 1% increase in $FEV_1$%, $DE_{TB/FB}$ decreased by 0.0028 (p=0.008; 95%CI -0.0048 to -0.0081) when adjusted for tidal breathing and age.

## CONCLUSIONS

- Our data shows a significant inverse relationship between COPD severity and $DE_{TB/FB}$. We interpret this to be a reflection of the expanded effect of dynamic airway collapse and air-trapping on the mobility of the diaphragm in forced versus tidal breathing in COPD. Thus, the ratio of tidal excursion to forced excursion approaches 1 as COPD worsens. Therefore, $DE_{TB/FB}$ provides an additional measure of COPD severity that is easily obtained from the DCXR.
- Limitations of this study include: small sample size, lack of ethnic diversity, and an unmatched control group.
- The static CXR does not provide the complete functional picture of the patient's respiration, even when combined with PFT. Frequently, it is not apparent where in the respiratory cycle the film was obtained and the importance of tidal breathing is not assessed at all.
- This data provides preliminary information for future studies using larger sample size, matched cohorts and varying ethnicities. Future validation of this method would allow for a clinically relevant option to assess COPD severity in the acute setting and for patients unable to perform PFTs.

## REFERENCES

1. Y. Yamada et al. European Journal of Radiology 87 (2017) 76-82.
2. 2. Yamada et al. Acad. Radiol. Vol 24, No4, April (2017).