MP458

DEVELOPMENT OF ESTIMATED CTR (ECTR) - ESTIMATION OF CARDIO-THORACIC RATIO WITHOUT THE INFLUENCE OF INSPIRATION

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Aim

To develop an estimated Cardio-Thoracic Ratio (eCTR) which is not subject to the influence of inspiratory level and which allows comparison of CTRs in the same patients.

Conclusion

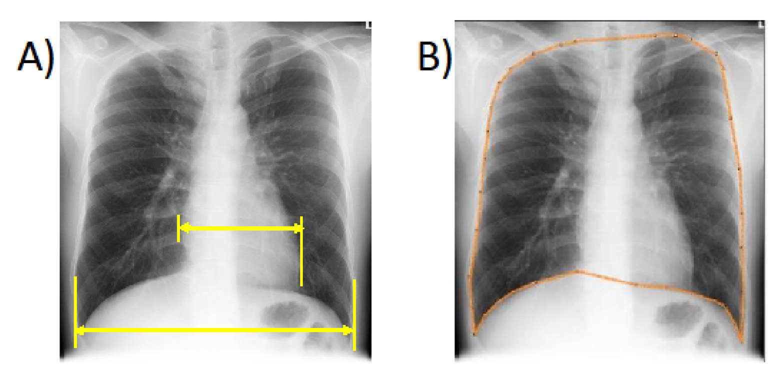
We developed two models of eCTR which are not influenced by inspiratory level. eCTR with consideration of the individual was as accurate as eCTR based on group averaged data without consideration of the individual.

Background

Cardiothoracic ratio (CTR) is useful in the assessment of dry weight in hemodialysis (HD) patients[1]. In Japan, most HD patients undergo chest x-ray (CXR) every month. JSDT Guidelines introduced a standard method of assessing dry weight by comparison of CTRs in the same HD patients[2].

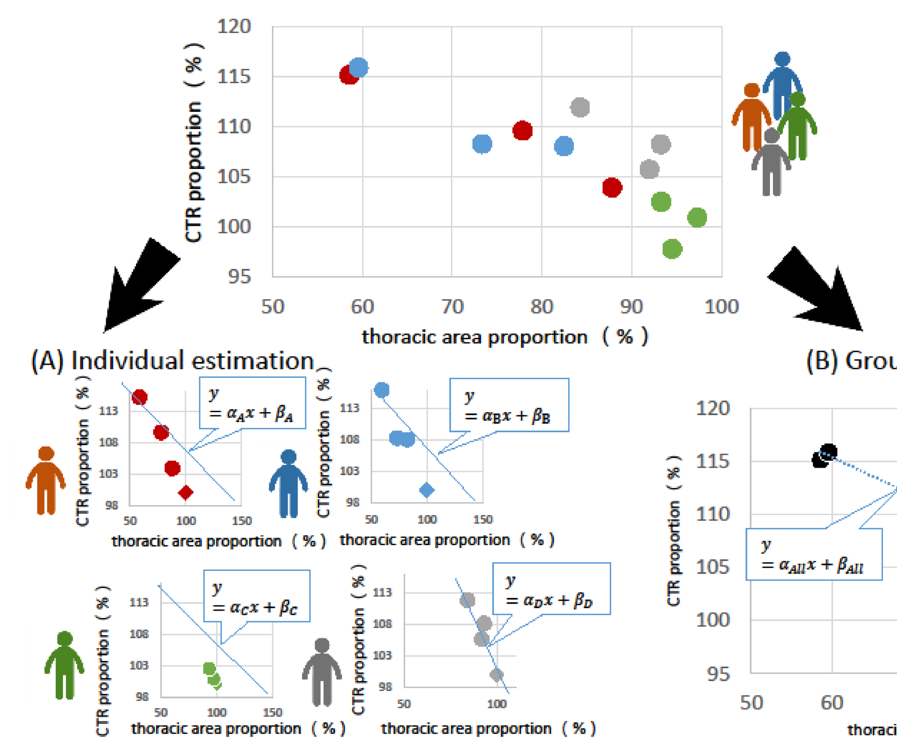
However, CTR is greatly dependent on inspiratory level[3], and CTRs measured at different times cannot be easily compared within the same patients. As a result of this fluctuation width of CTR, CTR assessed on CXR did not improve prediction of mortality in HD patients[4].

We developed an estimated CTR (eCTR) which is not subject to the influence of inspiratory level and which allows comparison of CTRs in the same patients.



The upper yellow arrow shows maximal cardiac width. The lower yellow arrow shows maximal thoracic width. The orange line covers the border of thoracic area.

Figure 1. Clinical assessment of cardiothoracic ratio and aortic arch calcification.
A) Measurement of cardiothoracic ratio (CTR). CTR is equal to the maximal cardiac width divided by thoracic width, as shown.
B) Measurement of thoracic area. Thoracic area is composed of the diaphragm and rib cage, as shown. We traced the line of the diaphragm and rib cage on the chest X-ray using the polygonal method and measured this area.



These proportions mean the proportions at 2/3 and 1/3 of the inspiratory level and maximal expiratory level to the maximal inspiratory level.
Circle showed at 2/3 and 1/3 of the inspiratory level and maximal expiratory level.
Diamond showed at the maximal inspiratory level.

Figure 2. The association of Individual estimation and Group average

Methods

The participants were 84 volunteers (Table 1). Posteroanterior CXR were taken at the maximal, 2/3 and 1/3 inspiratory levels and at the maximal expiration level in close succession. The CTR and thoracic area in each CXR were measured four times by a radiologist and a nephrologist, and the averaged value was used. We measured CTR and thoracic area using Image-J[5] (Figure 1).

First, we estimated CTR from the thoracic area at the same inspiratory level. Using these estimations, we estimated CTR at the 2/3 and 1/3 inspiratory levels and compared the estimated CTR and measured CTR at the same inspiratory level. We estimated CTR two ways, using individual and group averaged data, as follows (Figure 2).

(A) Individual estimation

1st Step: We estimated CTR proportions from the thoracic area proportion in individual subjects. We used the proportions at 2/3 and 1/3 of the inspiratory level and maximal expiratory level to the maximal inspiratory level.

2nd Step: Because the taking of a number of CXRs in close succession is problematic, we estimated the expression of CTR proportion from the thoracic area proportion of the individual using CTR, ompared CTRs using Pearson correlation.

thoracic area, epicardial fat and gender information obtained from a single CXR and patient information. All values were obtained from CXR at the maximal inspiratory level.

3rd Step: To obtain the individual estimation of CTR proportion, we adapted the information for the individual at the maximal inspiratory level to the estimation we obtained in the 2nd step.

4th Step: We adapted the thoracic area proportion at 2/3 and 1/3 of the inspiratory level to estimate CTR proportion at these inspiratory levels.

(B) Group average

We estimated CTR proportion from the thoracic area proportion averaged across all participants. We used the proportions at 2/3 and 1/3 of the inspiratory level to the maximal inspiratory level.

Second, using these estimations, we then estimated eCTR, namely CTR at the maximal inspiratory level estimated from the measured CTR and thoracic area at 2/3 and 1/3 of the inspiratory level. We compared eCTR with CTR measured at maximal inspiratory level. We used the bootstrap method for estimation, and compared CTRs using Pearson correlation.

Results

CTR increased across inspiratory levels and thoracic area decreased across inspiratory levels (Figure 3).

On comparison of estimated and measured CTR at the same inspiratory level, correlations were 0.877 [95%CI 0.829-0.915] for individual data and 0.891 [95%CI 0.848-0.925] for group averaged data (Figure 4A). On comparison of eCTR with measured CTR at maximal inspiratory level, correlations were 0.915 [95%CI 0.877-0.944] and 0.890 [95%CI 0.842-0.927], respectively (Figure 4B). There were no significant differences between the two groups in either comparison.

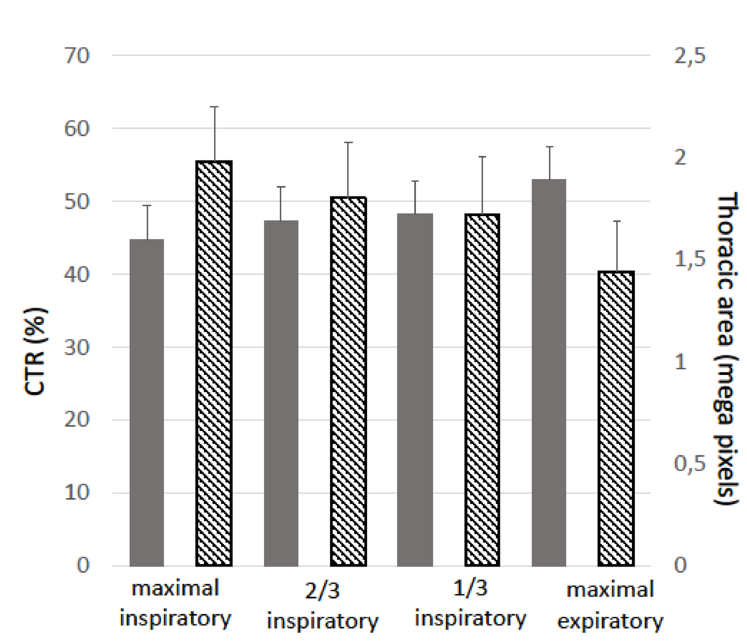


Figure 3. Association of inspiratory levels and CTRs, thoracic areas.
▩ : CTR
▧ : Thoracic area (Mean and Standard deviation)
CTRs significantly increased across inspiratory levels. Thoracic areas significantly decreased across inspiratory levels. (the nonparametric test for trend)

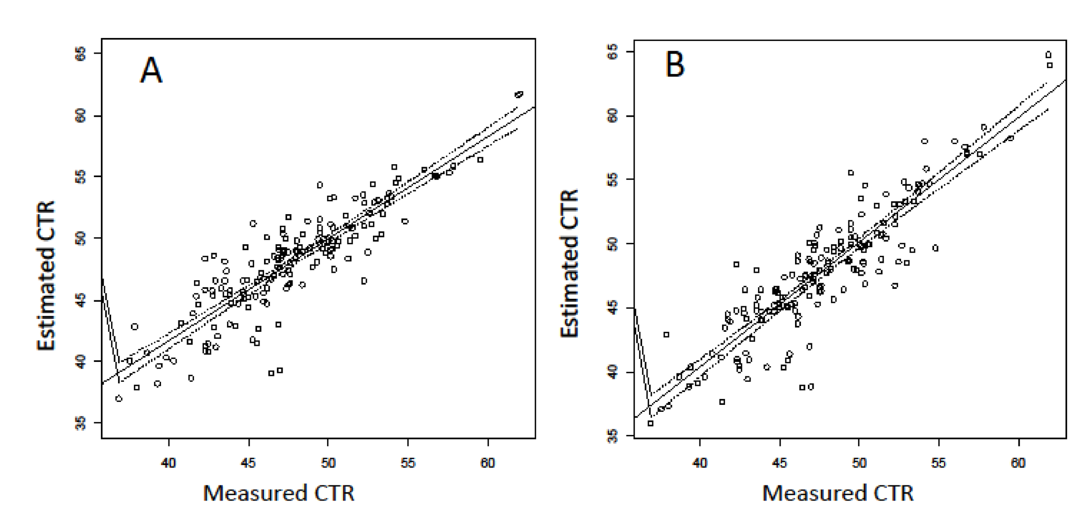


Figure 4A. Comparison of estimated CTR with measured CTR at same inspiratory level.
A: Individual estimation
B: Group average

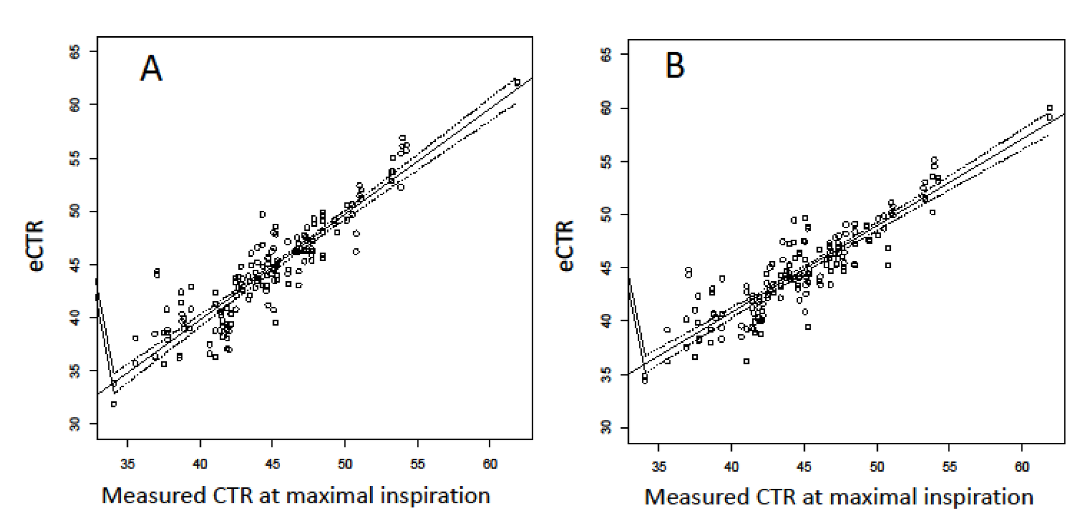


Figure 4B. Comparison of eCTR with measured CTR at maximal inspiratory level.
A: Individual estimation
B: Group average

Table 1. Background information of participants
Continuous variables are expressed as mean (standard deviation) and count data as number [percentage].

Number of participants	84
Age (years)	50.6 (12.9)
Gender (Male：Female)	40:44
Height (cm)	163.8 (8.39)
Weight (kg)	60.8 (11.4)
CTR (%)	44.67 (4.76)
Thoracic area (mega-pixel)	1.98 (0.27)
Epicardial fat (Number)	47 [55.9]

Strengths

eCTR is not influenced by inspiratory level. eCTRs measured at different times can be easily compared within the same patients.

Limitations

There are several limitations to the adaptation of our study. First, our study included healthy volunteers who were not HD patients. A validation study among HD patients is needed. Second, we measured CTRs and thoracic areas by manual procedures, which gives a wide range of measurement error. Automatic CTR and thoracic ares measuring systems can deliver a narrow range of measurement error. Third, eCTR has the premise that thoracic areas at maximal inspiratory levels will not change. Patients with pleural effusion cannot use eCTR.

Conclusion

We developed two models of eCTR which are not influenced by inspiratory level. eCTR with consideration to the individual was as accurate as eCTR based on group averaged data without consideration of the individual. We plan to perform a validation study using HD patients' CXR.

Reference

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Dialysis. Extracorporeal dialysis: techniques and adequacy.

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