特別掲載

Studies on the Quantitative X-ray Diagnosis Part 2: A color display method of pulmonary ventilating function by means of filmmetry

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定量的X線診断法の研究 第2報 フイルム計測法による肺換気量のカラー表示

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目的),深吸気時,深呼気時2枚の胸部X線フイルムの濃度差を測光積算させることにより,肺換気機能の量的計測を行なう試みを前回に報告したが[1],この装置のフイルム濃度—肺組織密度変化の直線性をサーボ増巾器により光源ランプの光度を非直線に変化することにより改善し測定精度の向上を図つた.この装置を利用して肺換気の状態を視覚的に表現する試みを行ない,興味ある結果を得た.

方法),光電子増倍管 MS-9S と小型ランプを利用した2channel の測光部により2枚のX線フイルムを同期的に走査する.双方の光電流を増巾した後,差動増巾器により差を計算しこの信号の大きさによりこれを5つのレベルに分割し Color discriminatorにより5色のペンを動作させる.ペンはそれぞれ,緑(最小),青,赤,黒,赤点線(最大)となつている.このペンは測光部と機械的連動している為,走査終了後記録紙に描かれた図形は,肺の呼吸運動を色彩的に表現する.

結果),正常人男性においては肺下野の密度変化が大きく,上野に行くに従いこの傾向は漸減しているのに対し,女性においては中,下肺野に変化が大きく,上野ではその程度が少ない.

約20例の各種疾患について計測を行なつたが程度の差こそあれいずれの例においても,正常側と異なつた肺呼吸運動の障害を示すパターンが得られた.本方法によりフイルムのみの計測によつても或る程度の肺の呼吸運動の平面分布を知ることが可能であり,X線写真の観察と併用することにより肺疾患の診断の向上に役立つものと考える.

Introduction

The filmmetric method for the quantitative and regional analysis of pulmonary ventilating function was reported in the previous paper[1]. This report deals with a two dimentional color display system

for pulmonary function.

Certain new devices added to the scanning system will be presented in detail.

Method and Material

The block diagram of new type film scanning system is shown in Fig. 1. The principle of substractive photometric scanning is same as the proto type.

Without any correction to the photometry, the relationship between the thickness of water phantom and the photo-current will be a kind of sigmoid curve shown in Fig. 2. The principle of improved type correction system is appeared in the block diagram. This is a feed back system consisted of servo driven brightness control of light sources. The output of each photomultiplier tube is put in the servo system which drive the non-linear potentiometer. Well adjusted feed back roop can straighten the filmmetric characteristics fairly satisfactorily.

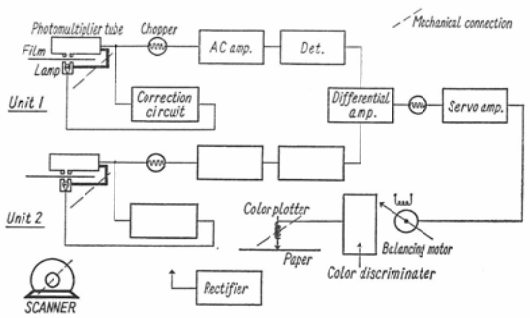


Fig. 1. The block diagram of new type film scanning system.

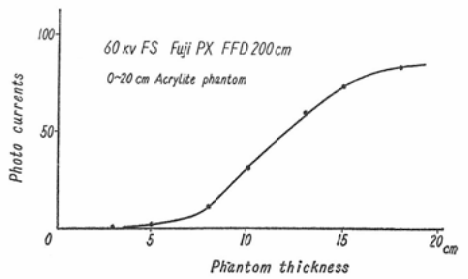


Fig. 2. The relationship between the thickness of water phantom and the photo-current.

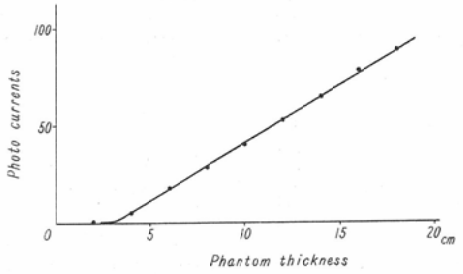


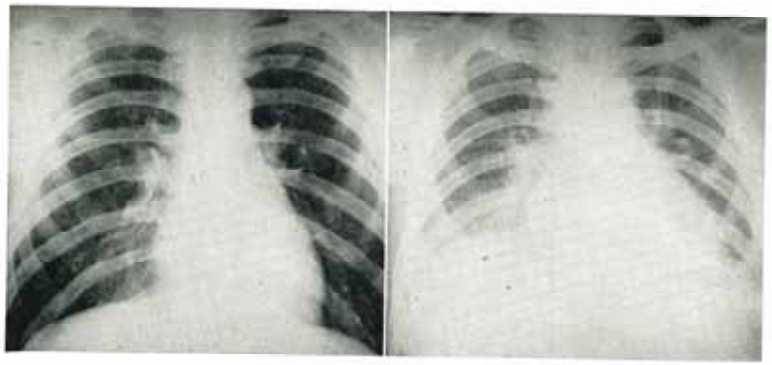
Fig. 3. An example of corrected chacteristics.

An example of corrected characteristics is shown in Fig. 3.

The feed back control of brightness, at the same time, enabled us to extend the range of measurement up to density of 3.

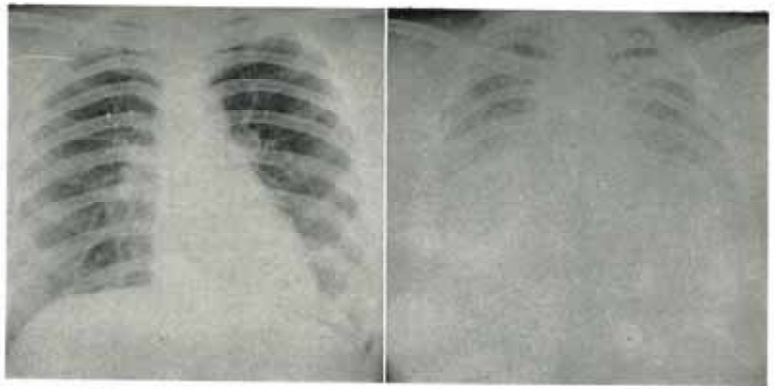
The time response of lamp will be the limiting factor in this system. The estimated upper limit of our machine was about 5 cps.

The linearized substractive output which corresponds to the amount of ventilation at the measuring point is supplied to the color discriminater. According to the input level, one of 5 stepped color pens



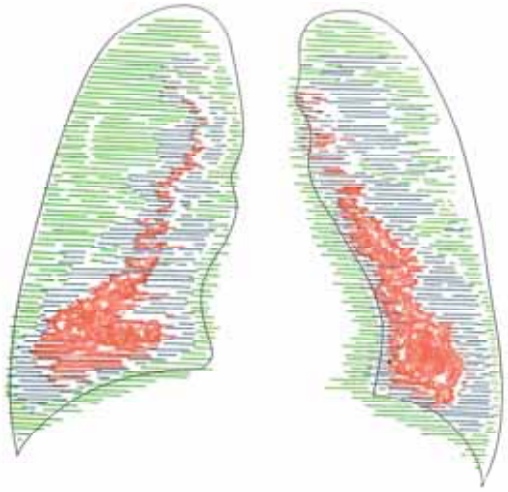
Max. inspiration　　Max. exspiration

Fig. 4　Chest X-ray films of 26 years old healthy man.

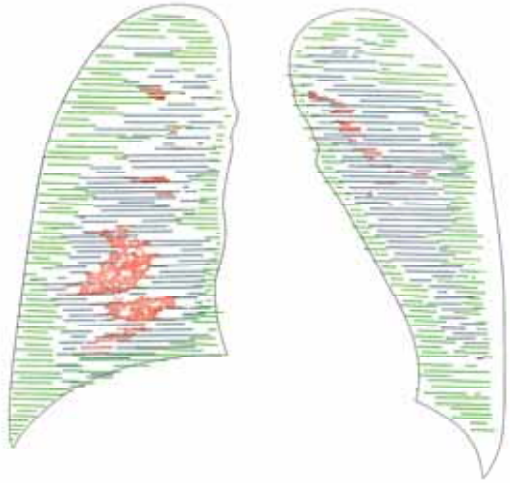


Max. inspiration　　Max. exspiration

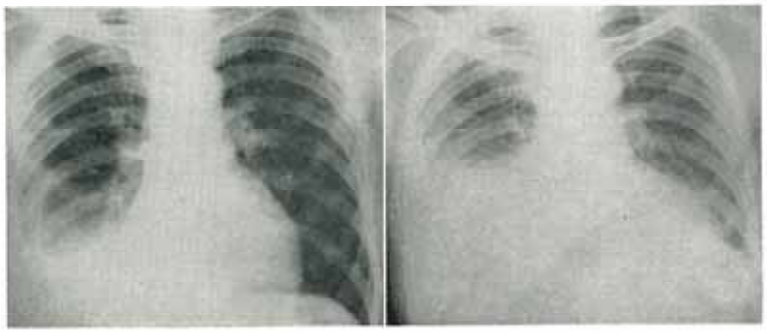
Fig. 5　Chest X-ray films of 33 years old healthy woman.



Color display of PVF, of fig. 4.

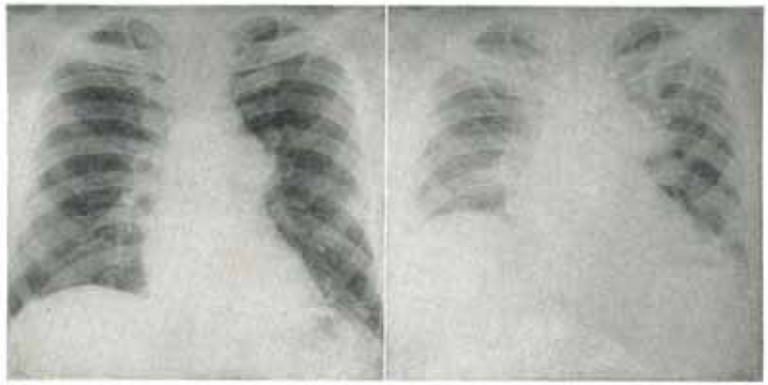


Color display of PVF, of fig. 5.



Max. inspiration　　Max. exspiration

Fig. 6a, Case1. 54 years old man. Right exsudative pleurisy.



Max. inspiration　　Max. exspiration

Fig. 7a, Case2. 55 years old man. Partial pulmonary emphysema.

Fig. 6b, Case 1. Color display of PVF.

Fig. 7b, Case 2. Color display of PVF.

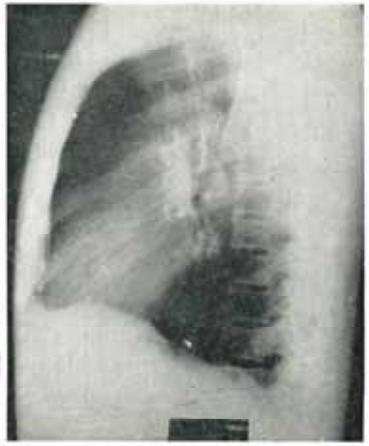


Fig. 7a

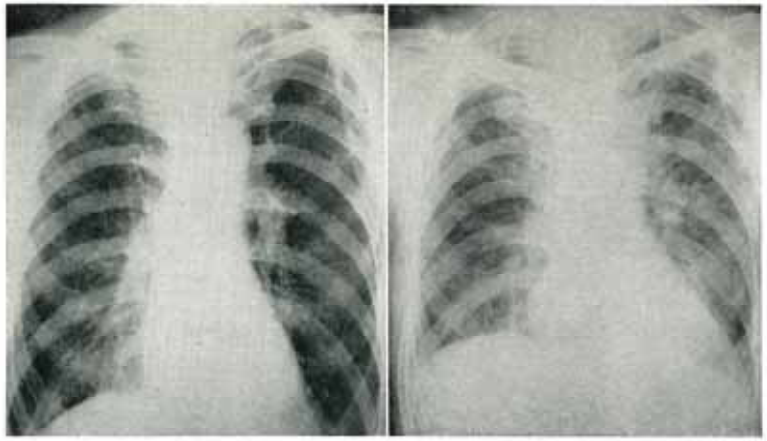


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Fig. 8a, Case 3. 70 years old man. Chronic bronchitis.

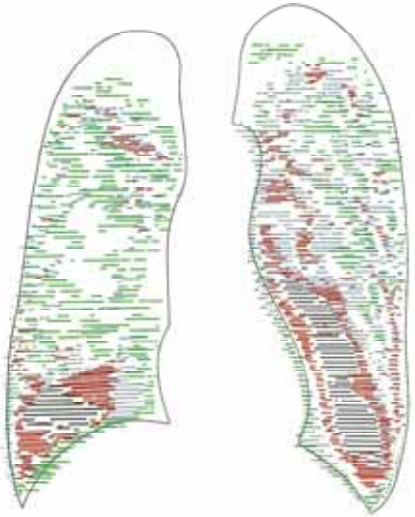
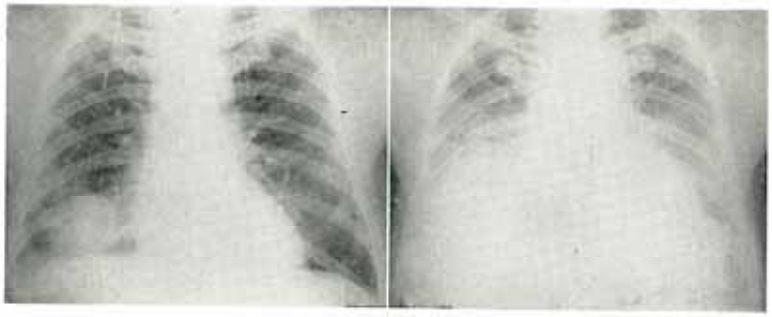


Fig. 8b, Case3. Color display of PVF.



Max. inspiration　　Max. exspiration

Fig. 9a, Case4. 59 years old man. Bronchogenic cancer of right lower lobe.

Fig. 9b, Case4. Color display of PVF.

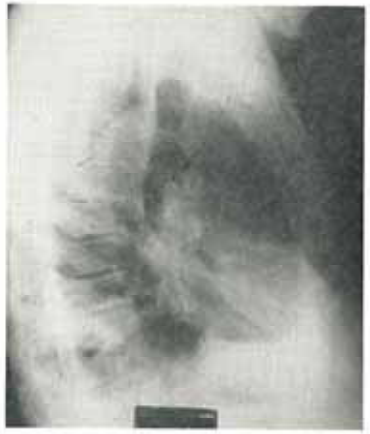
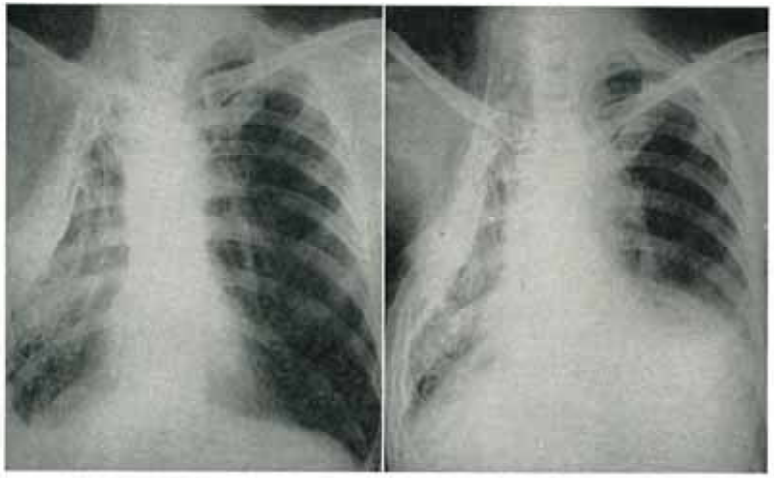


Fig. 9a



Max. inspiration　　Max. exspiration

Fig. 10a, Case5. 49 years old man. Status after thoracoplastic surgery.

Fig. 10a, Case5. Color display of PVF.

-green (min.), blue, red, block and dotted red (max)- is driven down on a recording paper. After the completion of area scanning, a colored display of pulmonary ventilation will be clearly and quantitatively recorded.

Results

1) Normal cases

Fig. 4 shows the result obtained from X-ray films of 26 years old healthy man. This is a typical finding for normal male adults.

Fig. 5 shows the result obtained from X-ray films of 33 years old healthy woman. The major difference between both sex lies in the vertical distribution of ventilation coming from the difference of mode of respiration.

2) Pathological cases

Case 1: 54 years old male. Right exsudative pleurisy. Fig. 6

He had complains of slightly elevated fever up to 37°C and irritating cough through last one month.

X-ray findings and color display of P.V.F. (pulmonary ventilation function):

Diffuse retention of effusion on his right lowere area. Right lung is deviated upwards, however, it preserves a ventilating function fairly well. This suggests that the process is rather fresh and no remarkable adhesion is occuring.

Case 2: 55 years old male. Partial pulmonary emphysema of left lingula. Fig. 7

March 1963, he had common cold like symptoms - cough and sputum.

March 1964, small amount of bloody sputum.

April 1964, he felt a slight difficulty at inspiration.

May 1964, he was found to have an atrial septal defect.

X-ray findings and color display of PVF:

A ventil occlusion of left B_{4+5} due to the pressure from the hypertrophic atrium and pulmonary artery is the cause of partial emphysema appeared in the left middle area. The color display of this case clearly described the defect of PVF. at this area.

Case 3: 70 years old male. Chronic bronchitis. Fig. 8

May 1963, he had an attack of fever up to 38°C and slight dysponea. Mucus and pus were found in sputa.

Since then he had been given antibiotics continuously.

X-ray findings and color display of PVF:

Multiple flecked shadows are scattered all over the entire lung. The mixture of pulonary fibrosis and emphysema suggests the chronic bronchitis of long standing. The extent of emphysema is more extensive in the right side. Color display of PVF. shows a markedly reduced ventilation in the right lung and an irregular pattern in the left side. The irregular patterns of left lung are the result of vertical shift of flecked shadows. There was an interesting fact that proved the accuracy of filmmetric method. R-L ratio measured by bronchospirometry was reported to be 0.545:0.455. This value do not agree with the color display of PVF. R-L ratio calculated by filmmetry was 0.438:0.562. Having a suspicion on these results, the bronchospirometry was repeated. This time R-L ratio was 0.418:0.582 which fairly agreed with the filmmetry. This suggests that the filmmetric method is more objective and more reliable than the bronchospirometry.

Case 4: 59 years old male. Bronchogenic cancer of right lower lobe. Fig. 9

Nov. 1963, A round massive tumor like shadow was detected by chance of mass survey.

X-ray findings and color display of PVF.:

Only a slight derease in ventilation is seen in the right lower area just fitting to the tumor.

The other part of lungs seems to be almost normal.

Case 5: 49 years old male. Status after thoracoplastic surgery. Fig. 10

1955 he had an operation of thoracoplasty on his right thorax for the purpose of treatment of tuberculosis.

X-ray findings and color display of PVF.

PVF. of right lung is extremely diminished. Major part of PVF. is carried on by left lower lobe. This case has a defect of PVF. on his left upper area on account of pleural adhesion, which is clearly shown on the color display.

Discussion

There has been no practical method to describe a pulmonary ventilating function in a two or three dimentional display.

In the past, R-L ratio was measured chiefly by bonchospirometry. Recently radiological methods became to be studied.

Our method, substractive measurement of a pair of chest film taken at exspiration and inspiration, is the first trial in the quantitative application of radiological method for the pulmonary function analysis. The color display system presented in this paper has expanded its practical value in the visual presentation of both images and functions from the same film sources.

The another advantage is the saving of time and costs.

Further progress of this method will be expected in the field of dynamic studies of X-ray TV and motion motion pictures.

Conclusions

A two dimensional color display system for pulmonary ventilating function study was presented. This method has following advantages.

1) It can reduce a burden of clinical examinations.
2) It is an objective and quantitative method.
3) Immediate and two dimentional visualization is possible with this method.
4) Entire process of measurement can be operated automatically.

Acknowledgement

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Reports based on this study were given at the 11th International Congress of Radiology, Rome, Sep. 1965, 6th International Conference on ME & BE, Tokyo, Aug. 1965, and 24th Annual Meeting of Radiological Society of Japan, Tokyo, April 1964.

Reference

1) Takizawa, M. and Umegaki, Y.: Nippon Acta Radiol. 25, 169—186, 1965