fizjoterapia polska
nr 3/2016 (16)

Zastosowanie wskaźnika relacyjnego Wr w diagnozowaniu radiologicznym

Using Relation Index Wr in Radiologic Diagnosis

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Streszczenie

Wstęp. W postępowaniu leczniczym ze względu na strategię postępowania oraz ocenę zmian ważne znaczenie ma precyzyjna diagnoza medyczna oraz fizjoterapeutyczna. W pracy uzasadniono, że zdjęcie rentgenowskie klatki piersiowej oceniane w klasyfikacji ILO (International Labour Organization) jest mniej precyzyjną metodą w radiologicznym diagnozowaniu pylicy krzemowej niż badanie HRCT klatki (High Resolutio Computed Tomography).
Cel pracy. Zastosowanie wskaźnika relacyjnego Wr w diagnozowaniu guzków pylicznych w klasycznej radiografii ocenianych w klasyfikacji ILO oraz uzyskanych metodą HRCT dla zbadania efektywności obu metod.
Materiał i metoda. Z grupy 358 pacjentów z rozpoznaną pylicą krzemową wybrano 65 mężczyzn, u których badania HRCT klatki piersiowej zostały wykonane w odstępie nie dłuższym niż 6 miesięcy od ostatniego zdjęcia rtg w klasyfikacji ILO. U każdego pacjenta na zdjęciu rtg oraz badaniu HRCT zmierzono średnice guzków najmniejszych i największych. Obliczono następnie średnie wartości wyników pomiarów guzków w każdym rodzaju badań.
Do opracowania wyników zastosowano następujące metody statystyczne: skalę T_1 [1], wskaźnik relacyjny Wr, w przedziałach: Wr∈[0,9; 1,1], Wr<0,9 oraz Wr>1,1. W przedziałach tych obliczono współczynniki korelacji między średnicami guzków występującymi w klasyfikacji ILO i HRCT metodą Pearsona.
Wyniki. Korelacja między średnimi średnicami guzków w poszczególnych przedziałach Wr jest wysoka lub bardzo wysoka a zależność znaczna lub bardzo pewna i H0 odrzucono (wyjątek stanowi przedział Wr>1,1 dla rozetek). Wykazano zatem, że zdjęcie rtg klatki oceniane w klasyfikacji ILO i badanie HRCT w podobny sposób pozwalają diagnozować stan chorobowy- pylicę krzemową płuc, jednak rodzaj guzków pozwala wykryć tylko badanie HRCT.
Wnioski. Metoda HRCT jest efektywniejsza niż klasyczne zdjęcie rtg klatki w badaniu pylicy krzemowej płuc, ponieważ wykrywa typy guzków, a mianowicie centrilobularne, podopłucnowe, peribronchowaskularne, rozetki i drzewo w pąkach.

Słowa kluczowe:
ILO, HRCT, wskaźnik relacyjny, skala T_1, diagnoza, pylica płuc, fizjoterapia

Abstract

Introduction. In treatment procedure, due to strategy and evaluation of changes, high importance has precise medical physiotherapeutic diagnosis. In this study it was substantiated that the chest X-ray picture evaluated in ILO (International Labour Organization) classification is less precise method in diagnosis of silicosis that HRCT (High Resolution Computed Tomography) examination.
Purpose of This Study. Using the relative index Wr in diagnosing silicosis nodules in classical radiography evaluated in ILO and received using the HRCT method to check effectiveness of the both methods.
Material and Method. From the group of 358 patients with diagnosed silicosis, 65 males were selected in whom the HRCT chest examinations were made in an interval not longer than 6 months from the last X-ray picture in ILO classification. In each patient on the X-ray picture and the HRTC exam the diameters of the smallest and the biggest nodules were measured. Then, an average values from nodule measurements were calculated in each exam.
To achieve results, the following statistical methods were used: scale T_1 [1], relation index Wr, in intervals: Wr∈[0.9; 1.1], Wr<0.9 and Wr>1.1. In these intervals, the correlation coefficients between nodule diameters in ILO classification and HRCT using Pearson's method.
Results. The correlation between average nodule diameters in individual Wr intervals is very high or very certain and H0 was rejected (exceptional is Wr>1.1 interval for rosettes). Therefore, it was demonstrated that the chest X-ray picture evaluated in the ILO classification and the HRCT examination similarly allow diagnosing the disease - silicosis, but the type of nodules may be found only using the HRCT.
Conclusions. The HRCT method is more efficient than the classic chest X-ray as it detects nodule types, namely centrilobular, under pleural, peribronchovascular rosettes and tree budding.

Key words:
ILO, HRCT, relation index, T_1 scale, diagnosis, silicosis, physiotherapy

Introduction

In the treatment procedure, due to strategy and evaluation of changes, high importance has precise medical physiotherapeutic diagnosis.

In radiology detection of a pathology consists in its imaging on the photograph. The basic method of diagnosing the silicosis is, according to recommendations of the International Labour Office (ILO) - a conventional X-ray picture in rear-front (P-A) projection [2, 3, 5, 6, 7]. The silicosis pathology in each patient may be imaged with the classic chest X-ray picture, evaluated in the ILO classification or using the High Resolution Computed Tomography - HRCT) [2, 4, 5, 7, 8, 9]. In examined patient the smallest and biggest nodules were measured on plates obtained using the ILO and the HRCT method. Average module diameters were presented in T_1 [1] scale according to the formula:

$$y = 10z + 50,$$

where z – standardized result.

The relation index Wr was defined:

$$Wr = \frac{y_{ik}}{y_{ik1}}$$

while: $y_{i,k}$ – result for T_1 scale nodules in X-ray method in i-patient

$y_{i,k1}$ – result for T_1 scale nodules in HRTC method in i-patient.

From the estimation of the Wr relation index, the three intervals were obtained:

$$Wr<0.9;\ Wr\epsilon[0.9;\ 1.1];\ Wr>1.1$$

For results from each interval the Pearson's correlation coefficient was calculated between nodule diameters received in X-ray and HRCT method.

The correlation between average nodule diameters in individual Wr intervals is high or very high, and the correlation is significant or very certain, H0 was rejected (exceptional is Wr>1.1 interval for rosettes, Table 1). Therefore, the methods according to ILO and HRCT were recognized as equivalent in diagnosing the silicosis, but the HRCT method is more effective than the classic radiography (ILO), because it detects the nodule types as: centrilobular, under pleural, peribronchovascular rosettes and tree budding [4, 5, 7, 8, 9].

Purpose of This Study

Using the relative index Wr in diagnosing silicosis nodules in classical radiography evaluated in the ILO classification and received using the HRCT method to check effectiveness of the both methods.

Material and Methods

The examinations were conducted in 2000 – 2007 in the Provincial Labour Medicine Centre in Kielce, in Consultation and Diagnosis Department. From the group of 358 patients with diagnosed silicosis, 65 males were selected in whom the HRCT chest examinations were made in an interval not longer than 6 months from the last X-ray picture evaluated in the ILO classification. The age of respondents ranged 33–81 years, $\bar{x}$ = 61 years, SD 10.31.

For each patient the smallest and the biggest nodule diameters were measured on X-ray picture in the ILO classification and the HRCT. Then, for each patient the average values from nodule measurements were calculated in both examinations.
To find the quasi uniform population, the relation index was introduced in the form:

$$Wr = \frac{y_{ik}}{y_{ik1}} \quad (1)$$

where: $y_{i,k}=10zi + 50$ (2)
value of result in ILO classification (k) in i-patient in scale T_1

zi – standardized result in ILO classification
$y^{i,k}=10zi, + 50$ (2')
result in T_1 scale in HRCT tests (k_1) in i-patient
z_i – standardized result in HRCT tests
Because, the average value of standardized result is always equal to zero (0), the average value of results in T_1 scale is always equal to 50, since ýśr = 10.0 + 50 = 50
To determine the effective interval for Wr relation index, that is 1 neighbourhood, the following operation definition was adopted [8]:
1. The standardized result was taken into account (1), that diverges from zero by (+1), and the standardized result (-1) that diverges from zero by (-1).
2. Standardized results 1 and -1 were referred to a critical value at the confidence level α =0.05 that was obtained from student's t-distribution matrices, namely: $t_{0.05,\infty} = 1.96$.
Received

$$z = \frac{1}{1.96} = 0.5102 \approx 0.5$$

The last value was used in the formula y = 10z + 50, obtaining y = 10.0.5 + 50 = 55. Analogical procedure was applied for (-1) value:

$$z = \frac{-1}{1.96} = -0.5102 \approx -0.5$$

obtaining

$$y = 10.(-0.5) + 50 = 45.$$

3. Results in T1 scale: 45 and 55 were referred to the average value in this scale, that is 50 and received:

$$\left[\frac{45}{50};\frac{50}{50};\frac{55}{50}\right] = [0.9;\ 1;\ 1{,}1] = 0(1)=0.1$$

means neighbouring for 1 point, which is a middle point of a circle with 0.1 radius, crossing points: 0.9 and 1.1.
Thus, if:

$$Wr \in 0(1) \leftrightarrow Wr \in [0.9;1.1].$$

From the above correlation it may be seen, that for the Wr relation index, three intervals were created:

$$Wr < 0.9;\ Wr \in [0.9;1.1] \text{ and } Wr > 1.1.$$

So, the question is justified: what is the correlation between average nodule diameters visible in X-ray picture per the ILO classification, and average nodule diameters received using the HRCT method in individual Wr intervals?

The answer to this question was obtained using the following formula for Pearson correlation coefficient (results come from the same patients)

$$r = \frac{\sum \bar{x}_1 \cdot \bar{x}_2}{\sqrt{\sum \bar{x}_1^2 \cdot \sum \bar{x}_2^2}}; \quad (3)$$

where: $\bar{x}_1$, $\bar{x}_2$ they are respective deviations from relevant diameters for variables x_1 and x_2.

significance of the correlation coefficient was tested using the formula:

$$t = r \sqrt{\frac{n-2}{1-r}}; \quad (4)$$

where: n – number of observation pairs
n-2 – degrees of freedom
r – correlation coefficient value.

For interpretation of the correlation coefficient, the following intervals were used [5](Table A)

Intervals	Correlation	Dependence
below 0.20	poor	almost insignificant
[0.20 – 0.40)	low	significant, but small
[0.40 – 0.70)	moderate	significant
[0.70 – 0.90)	high	considerable
[0.90 – 1.0]	very high	very certain

Results

Calculated correlation results for patients belonging to respective Wr intervals, together with its significance, are presented in Table 1.

Table 1. Correlation between values for average nodule diameters in ILO classification and types of nodules present in HRTC in sub-groups identified using Wr.

Types of nodules	Value interval Wr	Number of variable pairs N		Correlation coefficient r	Degrees of freedom df=s	Calculated value t	Critical value t_{α}=0,05, s	Decision on H_0
centrilobular	< 0.9	55	11	0.841	9	4.659	2.262	rejected
	[0.9; 1.1]		34	0.957	32	18.654	2.037	
	> 1.1		10	0.757	8	3.278	2.306	
under pleural	< 0.9	61	12	0.701	10	3.112	2.228	
	[0.9; 1.1]		35	0.962	33	20.319	2.035	
	> 1.1		14	0.844	12	5.452	2.179	
peribronchovascular	< 0.9	46	16	0.822	14	5.392	2.145	
	[0.9; 1.1]		16	0.974	14	16.035	2.145	
	> 1.1		14	0.788	12	4.437	2.179	
rosettes	< 0.9	27	8	0.895	6	4.928	2.447	
	[0.9; 1.1]		9	0.971	7	10.801	2.365	
	> 1.1		10	0.500	8	1.634	2.306	accepted
tree budding	< 0.9	30	11	0.820	9	4.297	2.262	rejected
	[0.9; 1.1]		10	0.984	8	15.567	2.306	
	> 1.1		9	0.765	7	3.141	2.365	

Table 1 indicates that there is at least high correlation between nodule diameters in images made using the ILO and the HRCT methods in individual intervals of the relation index Wr. The exceptions are rosettes when Wr>1.1, as the correlation is moderate, and the zero hypothesis (H0) is accepted.

Therefore, general conclusion is as follows: the methods ILO and HRCT are equivalent, because we may anticipate diameters of nodules recorded in HRCT scans from images made using the ILO method, and vice versa.

Equivalence of both methods is only random for rosettes, when Wr>1.1.

The Table also indicates that the sizes for centrilobular, under pleural and peribronchovascular nodules are bigger than the sized for rosette and tree budding types.

It was also checked if such regularity is systematic or random for peribronchovascular nodules and rosettes.

For this purpose the structure index was used [10]:

$$u = \frac{\frac{m_1}{n_2} - \frac{m_2}{n_2}}{\sqrt{\frac{p \cdot q}{n}}} \quad (A)$$

where m_1, m_2 – distinguished sizes, namely:

$$m_1 = 46,\ m_2 = 30,$$
$$n_1 = n_2 = 65,$$

from where the average structure index p has value:

$$p = \frac{m_1+m_2}{n_1+n_2} = \frac{46+30}{65+65} = \frac{76}{130} = 0{,}58$$

then:

$$q = 1-p = 1- 0{,}58 = 0{,}42$$

Pseudo size n was calculated:

$$p = \frac{n_1 \cdot n_2}{n_1+n_2} = \frac{65 \cdot 65}{65 + 65} = 32{,}5$$

substituting the above values to A formula, it was received:

$$u = \frac{\frac{46}{65} - \frac{30}{65}}{\sqrt{\frac{0{,}58 \cdot 0{,}42}{32{,}5}}} = \frac{0{,}71- 0{,}46}{0{,}087} = \frac{0{,}25}{0{,}087} = 2{,}87$$

The H_0 hypothesis was rejected at confidence level $\alpha = 0.05$, since

$$u > u_\alpha = 2.87 > 1.96$$

Thus, non-accidental difference exits in sizes between peribronchovascular nodules and tree budding. It is non-accidental, 46>30, which means that we have bigger confidence in case of centrilobular, under pleural, peribronchovascular nodule than in case of rosettes and tree budding, as the sizes of centrilobular and under plural nodules are bigger than peribronchovascular nodules.

It confirmed by adopting the zero hypothesis (H_0) between sizes of rosettes and tree budding. As we have - tree budding m_1=30, and for rosettes m_2=27. Substituting to A formula, it was received:

$$u = \frac{\frac{30}{65} - \frac{27}{65}}{\sqrt{\frac{0{,}44 \cdot 0{,}56}{32{,}5}}} = \frac{0{,}46- 0{,}41}{0{,}087} = \frac{0{,}05}{0{,}087} = 2{,}87$$

Since the zero hypothesis was assumed: $u<u\ \alpha = 0.57<1.96$
This indicates that nodules type rosettes and tree budding occur less often than centrilobular, under pleural and peribronchovascular nodules.

Among the three intervals indicated by Wr, the interval Wrϵ[0.9; 1.1] is the one that is distinguished, as the correlation coefficients in this interval are close to unity, which means very high correlation. So, it may be concluded that individual patients whose results belong to this interval reach very high correlation due to tested variables.

Summarizing, it was determined as follows:
ILO and HRCT methods are equivalent in diagnosing the silicosis, but the HRCT method is more precise, because it detects nodule types, in particular for centrilobular, under pleural and peribronchovascular nodules. The occur more often in patients that rosettes and tree budding types.

Discussion

It was determined in the research that the correlation index in the interval Wr ϵ [0,9; 1,1] distinguished population for which correlation between diagnosing in the ILO classification and HRCT is very high and the relation is very certain, in that case H0 hypothesis was rejected. It means that the ILO classification and HRCT method in diagnosing nodule sizes may be regarded and equivalent.
Due to the fact that HRCT tests diagnose nodules as: centrilobular, under pleural, peribronchovascular, rosettes and tree budding, what may not be assessed from the chest X-ray per ILO classification, it should be stated that the HRCT is more precise in diagnosing the silicosis [3, 4, 5, 6, 11, 12]. Publications presenting hitherto approach described only advantages resulting from the HRCT test in diagnosing the silicosis, but did not included justification of comparing the ILO and the HRCT method [5, 6, 7, 8, 9]. The use of relation index Wr allows such justification and effective diagnosis.
Existing publications included views that the HRCT method is more useful in diagnosing the silicosis than the ILO method [4, 5, 6, 7, 11, 12]. There was no method to justify this fact. Demonstration of the both methods equivalence and indication that the HRCT method is more precise than the ILO method was possible with the use of Wr relation index, assuming types of modules from previous publications.
Clinical examinations are often analyzed incorrectly, in particular when using correlation coefficients. The statistical analysis method offered in this study represents an alternative approach based on simple calculations. Introduction of the new form of mathematic interpretation creates an opportunity to avoid errors in statistical analyses [13]. This fact will influence exact diagnosing of the patient in correct determination of the treatment program, including physiotherapeutic procedures suitable for the patient's expectations [14, 15, 16, 17].

Conclusions

1. Significant high correlations between nodule diameters indicate that the ILO and the HRCT methods are equivalent in diagnosing the silicosis.
2. The HRCT is more precise, as it detects nodule types, like: centrilobular, under pleural, peribronchovascular, rosettes and tree budding, and this is essential in diagnosing the silicosis.
3. If the relation index Wr belongs to the interval [0,9; 1,1], then high correlation exists between tested variables in each patient in this interval.

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