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DIAGNOSTIC SIGNIFICANCE OF SIMULTANEOUS PULSOOXIMETRY AND THERMOMETRY FOR RESPIRATORY PATHOLOGY IN YOUNG CHILDREN

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Introduction. The state of the microcirculatory bed plays a decisive role in the metabolic processes of organs and tissues. The intensity and direction of metabolic processes in tissue cells depend on the mass transfer of oxygen by blood [1].

At present, it is well known that in a number of severe infectious diseases, there is a significant violation of the microcirculatory transport properties of oxygen and oxygen utilization by tissues [2, 3]. Various indirect methods have been proposed to help objectively assess the state of the vascular bed. For the non-invasive assessment and detection of these metabolic and microcirculatory changes, current clinical protocols advise measuring saturation - tissue oxygen saturation (StO2) using pulse oximetry.

The software has the potential to detect hypoxemic conditions and early detection of decompensation of the cardiovascular and respiratory systems [4]. This ability to provide early warning has made the pulse oximeter an indispensable element in monitoring the condition of patients with disorders of the cardiovascular and respiratory systems.

The benefits of software have proven so clear that in 2014 the World Health Organization (WHO) updated its Integrated Management of Childhood Illness (IMCI) outpatient care guidelines for children and recommended the introduction of pulse oximetry to assess pneumonia [5].

However, methodologies for estimating StO_2 are very conflicting in the literature, and consequently results vary from study to study, making data comparison difficult and difficult to interpret.

One of the aspects of the controversial methodology is the measurement sites and the location of the sensors: fingers or toes, auricles, distal or proximal parts of the forearms, etc.). The most accessible places in young children to determine the peripheral blood circulation are the head and distal extremities.
How equivalent are these points for assessing the child's condition?

To answer this question, a comparison was made of one-time data on saturation and temperature obtained from different measurement points in young children suffering from respiratory pathology of the upper and lower respiratory tract. This approach reflects the relevance of research in the field of standardization of diagnostic methods.

Purpose of the study. To study the variability and clinical significance of the combined one-time indicators of saturation (StO_2) and local t^0 for different measurement zones in children with respiratory pathology. To achieve this goal, in 21 young children with acute respiratory pathology and in 10 children with community-acquired pneumonia, indicators of one-stage thermo- and oximetry of the extremities were studied and the data obtained were compared with the clinical features of the course of respiratory pathology.

Study design. The «null» hypothesis that preceded this study was that the measurement points on the distal parts of the limbs are equivalent and their arbitrary choice does not play a decisive role in assessing the severity of the condition of a sick child. The design of the study is a cross-sectional study of two groups of patients according to the Case-control type, followed by a comparative statistical analysis of the parameters of these groups.

Materials and methods of research

The study was conducted on the basis of the infectious diseases department for young children of the KNP "Odesa Regional Childhood Clinical Hospital" OOR ". The following devices were used in the study, which are directly available to each doctor: finger pulse oximeter, Little Doctor. Has an allowable error in measuring the pulse and saturation + -2%; non-contact infrared thermometer, Comedones company. Permissible distance for measuring t^0 1-10 cm, body t^0 range 32-43C^0.

The research process consisted in simultaneous measurement of saturation on 4 limbs and infrared thermometry on the head and limbs.

Interpretation of the nature of the relationship (correlation coefficient r) between the studied parameters was based on the following generally accepted norms:

$r < 0.25$ - no relationship; $0.25 < r < 0.5$ – correlation is weak;

$0.5 < r < 0.75$ - the relationship is moderate; $r > 0.75$ - strong relationship.

The significance of the discrepancy between the empirical (actual) and theoretical (expected) frequencies was tested taking into account the $\chi 2$ (chi-square) criterion. Statistical material was processed on the Microsoft Excel 2010 platform.

Selection criteria. The measurement was carried out only after eliminating a number of factors that distort the data of non-contact thermometry, including:

- contamination of the sensor from a previous measurement due to contact with the patient's skin;
- the presence of wet skin as a result of increased sweating;
- the presence of an air conditioner or a fan in the temperature measurement area;
- the presence of any ointment or creams in the treatment of concomitant skin diseases;
- weakened battery voltage of the thermometer;

- with motor restlessness of the child. During sequential thermometry of the forehead, back sides of the hands and feet, the temperature sensor was placed at a distance of 1-2 cm from the skin surface. The thermometer was turned off immediately after the sound signal.

The average time to perform infrared thermometry was from 3 to 5 seconds, pulse oximetry on one limb was 35-40 seconds.

Research results

Two groups of young children with respiratory pathology were studied. In the first group, 21 children with acute respiratory infection of the upper respiratory tract (URTI) were under observation. The average age of children in this group was 19 ± 5 months. The second group included 10 children with acute community-acquired pneumonia. Their age was 28,6 ± 5 months. In sick children, the following features of saturation were revealed (Table 1).

Table 1

Correlation coefficients between limb saturation and temperature in young children with URTI and pneumonia.

	Saturation		Thermometry	
Measurement points	URTI	Pneumonia	URTI	Pneumonia
Right hand- Left hand	- 0,031	+ 0,786	+0,946	+0,523
Right leg - Left leg	+ 0,408	+ 0,661	+0,958	+0,648
Right hand - Right leg	- 0,048	+ 0,407	+0,386	+ 0,264
Left hand - Left leg	- 0,017	- 0,099	+0,481	+0,363

As follows from the above data, in diseases of the upper respiratory tract, a weak correlation of indicators was noted only between the lower extremities (+0,408). Other combinations of peripheral saturation reflect the relative autonomy of saturation of the right and left halves of the body and upper limbs.

Pneumonia in children is characterized by a significant change in the redistribution of saturation: between the upper limbs there is a high level of positive correlation (+0,786), slightly lower, between the lower limbs the positive correlation increases (compared to children with URTI) to an average level (+0,661). The regulation of the right-sided circulatory circuit is enhanced: the correlation between the right limbs rises to a weak level (+0,407). The left circulatory circuit remains intact.

A gradation of saturation indicators was found in ARVI and the right hand in pneumonia:

- with URTI: *StO_2 L. hand > R. hand > L. leg > R. leg*;
- in case of pneumonia: *StO_2 R. hand > L. hand > R. leg > L. Leg*.

Thermometry indicators, carried out simultaneously with the determination of saturation, are reflected in table 2.

In contrast to saturation, correlation indicators in thermometry reflected the presence of a strong interaction for the hands (r = + 0,946) and legs (r = + 0,958) in patients with URTI, in contrast to a moderate relationship in pneumonia. The temperature correlation of the right limbs was +0,386, for the left:- +0,481.

The study of the temperature relationship between the forehead and limbs is shown in Table 2.

Table2

Correlation coefficients between limb and head temperature in young children with URTI and pneumonia.

Measurement points	URTI	Pneumonia
Right hand – Forehead	+0,424	- 0,221
Left hand – Forehead	+0,441	- 0,114
Right leg – Forehead	- 0,013	- 0,101
Left leg - Forehead	+0,064	+0,265

In URTI, there is a weak positive correlation between forehead temperature and upper extremities, and no interaction has been found between the forehead and lower extremities. In pneumonia, there is also no interaction between the studied parameters. An emerging trend towards a negative interaction can be noted - the higher the temperatures of the head, the more often cold extremities are detected.

The average temperature on the hands is higher than on the legs by 0,4-0,5 C^0 degrees and its gradation on the limbs is presented below:

- with URTI: t^0 *L.hand > R.hand > R.leg > L. leg;*
- in case of pneumonia: t^0 *R.hand > L. arm > L. leg > R. leg.*

This gradation of thermometry indicators indicates the dominance the indicators of the left hand in URTI and the right hand in pneumonia.

The presented correlation data on saturation and thermometry in various respiratory diseases in children show complex, sometimes multidirectional compensatory mechanisms of metabolic and circulatory adaptation in respiratory pathology in children. But they cannot answer the question of the standardization of such studies.

What is the informational value of the study? How equivalent for interpretation are the selected points of the body for the simultaneous measurement of saturation and temperature?

As a “null hypothesis”, the statement is accepted that the choice of a point for measuring body temperature and saturation is not significant.

To test this hypothesis, we used the method of calculating Pearson's $\chi 2$ (Chi-square) goodness-of-fit test, which makes it possible to check the significance of the discrepancy between empirical (observed) and theoretical (expected) frequencies.

When testing the "null" hypothesis, the averaged actual data on saturation levels and body temperature were extrapolated, as expected data, to the indicators of the upper and lower extremities, which made it possible, in the future, to assess the degree and reliability of the discrepancies between the actual and expected ones for the "null" hypothesis data. Tables 3 and 4 show the results of testing the "null" hypothesis for the assessment of saturation and thermometry, respectively.

Table 3

$\chi 2$ Value for Limb Saturation Values in Young Children with URTI and Pneumonia

Measurement points	URTI			Pneumonia		
	Degrees of freedom (n-1)	Values $\chi 2$	Confidence level (p)	Degrees of freedom (n-1)	Values $\chi 2$	Confidence level (p)
Right hand-Left hand	20	212,67	P < 0,001	9	47,94	P <0,001
Right leg - Left leg	20	230,59	P <0,001	9	117,61	P <0,001

The data presented in Table 4 reflect the high values of "chi-square", which indicates a significant difference in saturation indicators in sick children of both groups with varying measurement points on the limbs. Such a significant difference contradicts the null hypothesis.

Table 4

The value of $\chi 2$ for indicators of thermometry of the limbs of young children with acute respiratory viral infections and pneumonia.

Measurement points	URTI			Pneumonia		
	Degrees of freedom (n-1)	Values $\chi 2$	Confidence level (p)	Degrees of freedom (n-1)	Values $\chi 2$	Confidence level (p)
Right hand-Left hand	20	27,72	P > 0,1	9	2,34	P > 0,9
Right leg – Left leg	20	9,37	p > 0,9	9	230,61	P < 0,001

Testing the "null" hypothesis regarding the choice of points for thermometry reflected the insignificant differences in the measurement of temperature in children with URTI and the absence of a significant difference in the measurement of indicators

on the hands of children with pneumonia, which confirms the correctness of the "null" hypothesis. The assessment of thermometry on the lower extremities reflects a significant difference between the choice of limb, which denies the assumption of the independence of the points of measurement of saturation on the legs.

Discussion about the results

The above results showed that the measurement of saturation on the extremities did not confirm the "null" hypothesis. The revealed gradation of indicators indicates that in case of a more severe course of respiratory pathology, the right hand should be the point of choice:

with URTI: StO_2 *L. hand > R. hand > L. leg > R. leg;*

with pneumonia: StO_2 *R. hand > L. hand > R. leg > L. leg*.

With thermometry, evidence was obtained in favor of the null hypothesis: the temperature indicators between the right and left extremities do not differ significantly in URTI, but this pattern is not observed in the thermometry of the lower extremities in patients with pneumonia.

The divergent nature of the findings may indicate that the processes of saturation and thermoregulation are independent circuits of metabolism.

The revealed presence of a gradation of temperature and saturation indicators of the extremities may indicate the phenomena of redistribution of blood circulation between them as the severity of the disease increases. With ARTI, the data of the left hand are most indicative, and with pneumonia, the data of the right hand.

Conclusions.

1. Simultaneous determination of saturation and thermometry of the extremities is an additional bloodless, accessible method for examining sick children with respiratory pathology.
2. Indicators of saturation of the extremities depend significantly on the measurement points and do not confirm the "null" hypothesis.
3. Thermometry indicators reflect the absence of significant differences between different measurement points and confirm the "null" hypothesis.
4. With ARTI, the data of the left hand are most indicative. Pneumonia is the most indicative of the right hand.
5. The revealed presence of a gradation of temperature and saturation indicators of the extremities may indicate the phenomena of redistribution of blood circulation between them as the severity of the disease increases and serve as an indicator of the severity of autonomic disorders in respiratory pathology in young children.

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There is no conflict of interest.

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