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Comparison of pulse oximetry and clinical examination for proper tissue perfusion in congenital heart patients

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Abstract

Introduction: One way of monitoring angiographic organ is the clinical examination that is dependent on the accuracy of the person performing it; Therefore, human error may be high and require frequent examination is at least 24 hours after angiography. Meanwhile, checking for arterial or intravenous blood gases due to the small size of the vein and the arteries in children is difficult, unlike adults is difficult and requires skill and mastery in the field of venipuncture. Therefore, it is advisable to use simpler and less costly methods such as pulse oximeters to monitor organs that are more accurate and comfortable for the staff and patient. Therefore, this study was conducted to compare post angiography puls oximetry and physical exam in cardiac congenital of pediatric patients.

Methods: This study was conducted with 45 patients with congenital heart disease undergoing diagnostic or therapeutic angiography. They were selected by convenience sampling method from among patients referring to the angiography department of Vali-e-Asr Hospital in Birjand, Iran, in 2016. Trained personnel performed the clinical examinations, including temperature, color, and pulse check (dorsalis pedis and tibialis posterior) for both the angiographic and control organs. Pulse oximetry was also performed concurrently using the Massimo pulse oximeter for both organs and continued for up to 6 hours after angiography. Demographics form and patients' clinical records were used to collect data. The obtained data were analyzed in SPSS software (V: 23) using the Kappa test.

Results: The agreement between the pulse oximetry of the angiographic and control organs was mild only at one, two, and six hours after angiography, and was moderate three hours after angiography (kappa=0.656 after three hours).

Conclusions: Although there was no clinical agreement between pulse oximetry and clinical examination, Butaccording our findingspulse oximetry is moreaccurate, and given the results in the first one to two hours after angiographyevaluation of organ is more sensitivity.

Keywords: Pulse Oximetry; Clinical Examination; Congenital Heart Disease; Angiography

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Background

One way to monitor an organ after angiography is the clinical examination of the organ, including pulse touch and organ warmth, cold, and color control. This requires regular examination, at least in the first 24 hours after angiography.Zuppa (2014) showed that an accurate cardiovascular physical examination (CPE) performed by a trained and experienced pediatrician could indicate significant cardiac structural alterations in more than 25% of cases (1). Nevertheless, it is challenging and time-consuming to diagnose ischemia in children via clinical examination, and mistakes are possible to occur. Moreover, it is not easy to check for arterial or intravenous blood gases in children because of the small size of veins and arteries, and the procedure requires skill and competency in venipuncture. To monitor organs, therefore, one should employ more straightforward and cost-effective methods, which are more precise and convenient for both the staff and the patient(s). One symptom of organ perfusion is high peripheral oxygen saturation (SpO2), which is monitored through pulse oximetry.Pulse oximetry hasbeen suggested as a complementary method to physical examination in order to identify Critical congenital heart disease cases that cannot bediagnosed through conventional methods (2).

The pulse oximeter is a non-invasive medical device that checks oxygen saturation and pulsation (3) and is used to manage pediatric and adult patients as both a diagnostic and prognostic monitor (4). Given the discrepancy between the measurement of SaO2 via pulse oximetry and invasive techniques, the former is described as SpO2 (5). The results of Soh's study shows that the pulse oximeter is an excellent and readily available device in the emergency department and the operating room to assist in the diagnosis of the pulseless hand, and subsequently, to discern arterial injury in well perfused, post-fixation supracondylar fractures of the humerus(6). In children who have cyanotic forms of congenital heart disease (CHD), the arterial saturation may steadily range between 75% and 85%. In these children, clinical decisions concerning admission, the timing of cardiac catheterization, oxygen administration, or surgery are usually made on the basis of pulse oximetry readings (4). Nevertheless, SpO2 measurement may not be sufficiently accurate in several situations, as in critically ill patients receiving supplemental oxygen, and can be risky in case it results in higher values of oxygen partial pressure in the blood. Preterm newborns are particularly vulnerable to retinopathy of prematurity caused by high oxygen concentration in the blood (5). The results from Zuppa's study (2014) shows that the association of CPE and pulse oximetry allows for improved diagnostic accuracy (1). However, evidence suggests that pulse oximetry can identify 20–30% more hypoxic children compared with the mere application of clinical signs (7).

Despite the current evidence, further research is required to evaluate the impact of post-angiography pulse oximetry and physical examination in congenital heart patients. This study aimed to compare pulse oximetry and clinical examination in angiographic and control organs for proper tissue perfusion in congenital heart patients.

Materials and Methods

This descriptive-analytical study was conducted with 45 CHD patients in need of diagnostic or therapeutic angiography.The study population were selected by convenience sampling method from among patients referring to the angiography department of Vali-e-Asr Hospital in Birjand, Iran, in 2016. CHD patients undergoing angiography or interventional therapies (balloon valvoplasty, aortic valve stenting, patent ductus arteriosus, and atrial septal defect device closure by the coil and Amplatzer vascular plug), the stability of vital signs ; arterial and venous organ normal; and normal venous pathways such as umbilical, hepatic, and cervical vesselswere inclusion

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criteria.Informed consent of parents to collaborate in the research was obtained. The study protocol was approved by the Research Vice-chancellery of Birjand University of Medical Sciences. Clinical examinations, including temperature (Warmth and cold), pulse, and color of the organs (dorsalis pedis and tibialis posterior), were performed by trained personnel for both the angiographic and control organs. Pulse oximetry was also performed concurrently with Massimo pulse oximeter for both organs and continued after angiography for up to 6 hours. Data were collected using demographics form and patients' clinical records.

The sample size was calculated as n=40 based on $n = \frac{z^2 p(1-p)}{d^2}$ formula and Soh's study (6).

The obtained data were analyzed in SPSS softwarev.23 using the Kappa test. A more logical interpretation for the Kappa results is displayed in Table 1.

The protocol of the study was approved by the Research Departmentof Birjand University of Medical Sciences under the identifier4277.

Results

Of the 45 participants, 51.1% (n=23) were male and 48.9% (n= 22) were female, ranging in age from 4 days to 25 years. A total of 66.7% (n=28) were diagnosed with cyanotic and 31.1% (n=14) with acyanotic heart disease. Most of the patients (75.6%) did not have a disease history, while 15.6% suffered from Down syndrome. From among them, 4.4% received heparin; 13.3% had patent ductus arteriosus closure. Also, 8.9% had AS balloon, 2.2% had PS balloon, and 75.6% received no intervention. The frequency of clinical examinations in the angiographic and control organs is presented in Table 2 and Table 3. Table 4 displays the descriptive statistics of SpO2 for both angiographic and control organs before, during, and after angiography.

The Kappa agreement coefficient was used to measure the agreement level between angiographic organ examination and control organ examination. It was not larger than 0.2 in pulse and color control cases. This indicates the disagreement between the two methods in these cases. However, the agreement between the temperatures of the angiographic and control organs was minimal only before and two hours after angiography (kappa=0.290 before angiography and kappa=0.219 two hours after angiography).

The agreement between the pulse oximetry of the angiographic and control organs was mild only at one, two, and six hours after angiography, and was moderate three hours after angiography (kappa=0.483 one hour after angiography, kappa=0.366 after two hours, kappa=0.656 after three hours, and kappa=0.477 after six hours).

The agreement between the angiographic organ examination and pulse oximetry of organ undergoing angiography was not larger than 0.2 in cases of pulse and color control, indicating a disagreement between the two methods. However, the agreement between angiographic organ examination and pulse oximetry concerning temperature was, in some cases, minimal and weak (kappa=0.259 immediately after angiography, kappa=0.48 after one hour, kappa=0.526 after two hours, kappa=0.423 three hours later, kappa=0.316 four hours later, and kappa=0.300 after five hours).

Discussion

CCHD can often generate hypoxemia in newborns without visible cyanosis. Hence, pulse oximetry hasbeen suggested as a complementary method to physical examination in order to identify CCHD cases that cannot bediagnosed through conventional methods (2).

Overall, there was no clinical agreement between pulse oximetry and clinical examination in the present study. However, the results from Bakr's studyconducted with 5,211 newborns indicateda sensitivity of 31% for the mere pulse oximetry, 46% for CPE alone, and 77% for the combination of the two methods (8). Granelli's (2009) study conducted in a population of newborns shows

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that the association between pulse oximetry and CPE allows for an increased sensitivity rate of over 20% compared tothe two methods employed individually (9). Itis also obvious that the association between a proper CPE and pulse oximetry screening can significantly enhance diagnostic accuracy,increasing the chances and frequency of early diagnoses (8). Nevertheless, the clinical examination to detect ischemia in children is difficult, time-consuming, and highly prone to human error. More straightforward and cost-effective methods, such as pulse oximetry, are suggestible to monitor organs – methods that are more accurate and comfortable for the staff and the patient. Therefore, pulse oximetry is a low-cost intervention that can help decrease child mortality as it provides more effective diagnosis and monitoring of children with hypoxemia (7). The result of Scrimgeour's study (2017) revealed that peripheral pulse oximetry is convenient, non-invasive, and relatively low-cost; nonetheless, it generally overestimates the oxyhemoglobin saturation in CCHD children undergoing cardiac surgery (10).

Limitations of the study include the lack of cooperation of some patients for clinical examination, the need for drug interventions to create appropriate early perfusion, early discharge with personal desire, and few cases of pediatric cardiac angiography.

Table 1. Interpretation of Cohen's kappa values

	Level of Agreement					
	None	Minimal	Weak	Moderate	Strong	Almost perfect
Value of Kappa	0–0.20	0.21–0.39	0.40–0.59	0.60–0.79	0.80–0.90	Above 0.90

Adapted from McHugh ML. Interrater reliability: Te kappa statistic. BiochemiaMedica. 2012, Oct. 15; 22(3): 276-82.

Table 2. Frequency percentage of clinical examinations in organ undergoing angiography

Organ undergoing angiography	Pulse control		Color control		Warmth and cold control	
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
Before	97.7	2.3	97.7	2.3	90.9	9.1
During	93.2	6.8	97.7	2.3	84.1	15.9
After 1 hour	93.2	6.8	100.0	0.0	84.1	15.9
After 2 hours	88.6	11.4	100.0	0.0	84.1	15.9
After 3 hours	93.2	6.8	100.0	0.0	88.6	11.4
After 4 hours	95.5	4.5	100.0	0.0	90.9	9.1
After 5 hours	95.5	4.5	100.0	0.0	90.9	9.1
After 6 hours	93.2	6.8	100.0	0.0	95.5	4.5

Table 3. Frequency percentage of clinical examination in control organ

Control organ	Pulse control		Color control		Warmth and cold control	
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
Before	100.0	0.0	100.0	0.0	95.5	4.5
During	100.0	0.0	100.0	0.0	95.5	4.5
After 1 hour	100.0	0.0	100.0	0.0	97.7	2.3
After 2 hours	100.0	0.0	100.0	0.0	97.7	2.3
After 3 hours	100.0	0.0	100.0	0.0	97.7	2.3
After 4 hours	100.0	0.0	100.0	0.0	100.0	0.0
After 5 hours	100.0	0.0	100.0	0.0	100.0	0.0
After 6 hours	100.0	0.0	100.0	0.0	100.0	0.0

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Table 4. SpO2 descriptive statistics in angiographic and control organs

	SpO2 of organ undergoing angiography			SpO2 of control organ		
	Minimum value	Maximum value	Mean (Standard deviation)	Minimum value	Maximum value	Mean (Standard deviation)
Before	73	99	92.56 (5.81)	73	98	92.96 (5.26)
During	75	99	91.71 (6.16)	78	100	93.04 (5.12)
After 1 hour	72	98	91.27 (6.78)	78	100	92.68 (5.18)
After 2 hours	70	98	91.40 (6.29)	78	99	92.80 (5.33)
After 3 hours	76	99	92.02 (5.73)	77	100	92.80 (5.35)
After 4 hours	79	99	91.93 (5.53)	80	99	93.02 (5.08)
After 5 hours	69	98	91.91 (6.13)	80	100	93.47 (4.77)
After 6 hours	58	99	91.38 (7.07)	60	99	92.87 (6.68)

Conclusion

There was no clinical agreement between pulse oximetry and clinical examination. Given that clinical examination relies on the accuracy of the person performing it, human error may be high and require a regular examination for at least 24 hours after angiography. On the other hand, organ ischemia did not occur in the patients under study. It seems that pulse oximetry is a better means of monitoring organs. However, for definitive conclusions, more studies are needed with larger sample sizes.

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Conflict of interest

The authors declare no conflict of interest in this study.

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