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# The assessment of neonates' exposure to traumatic factors in the cardiac ward within the first 24 hours of hospitalization

## Ocena narażenia noworodków na czynniki traumatyczne w pierwszej dobie hospitalizacji w oddziale kardiologicznym

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(e) *substantive supervision of the study*
(f) *participation in the discussion*

## ABSTRACT

**Introduction**: During the first 24 hours of hospitalization, neonates with ductus-dependent CHD are exposed to a number of traumatic impulses arising from the need for necessary care and therapeutic procedures.

**Material and methods**: The studied group consisted of neonates in a stable condition, suffering from ductus-dependent CHD, monitored from the first to the fifth day of their life. The research involved the observation of 10 patients of the cardiac ward at the University Children's Hospital. The research was carried out by means of the following methods: observation with available assessment tools, such as author's questionnaire, CRIES scale, sound level meter and stopper.

**Results**: The total number of all procedures performed on the group of 10 neonates amounted to 622 per day. The average number of invasive procedures per day performed on one patient was 6.6, while the procedures connected with touching averaged at 57.3. The average daily noise level amounted to 72.2 dB; the total daily time of exposure to artificial light averaged at 87 minutes, with the average duration of a single lighting episode lasting 14.6 minutes. The average pain level of a neonate connected with chosen invasive procedures fell between 5 and 7 points in the CRIES scale.

**Conclusions**: The impact of traumatic factors disrupts the process of adaptation, may adversely influence further development of central nervous system, perception and sense organs and disturbs psychological development.

**Key words**: Traumatic factors, Neonate, Congenital heart disease

## STRESZCZENIE

**Wstęp**: Noworodki z przewodozależną wrodzoną wadą serca, są narażone w pierwszej dobie hospitalizacji na szereg traumatycznych bodźców związanych z działaniami pielęgnacyjno–opiekuńczymi oraz leczniczymi.

**Materiał i metody**: Grupę badawczą stanowiły noworodki z przewodozależną wadą serca w wieku od 1–5. doby życia, w stabilnym stanie zdrowia, urodzone o czasie. Badaniami objęto 10 pacjentów oddziału kardiologicznego USD w Krakowie. Metodę badawczą stanowiła obserwacja noworodków oraz ich ekspozycji na czynniki traumatyczne w pierwszej dobie hospitalizacji. Badano natężenie hałasu w sali, liczbę epizodów i czas ekspozycji na światło sztuczne w ciągu doby, liczbę traumatycznych procedur wykonywanych u pacjenta, poziom natężenia bólu, oraz oszacowano przybliżoną długość snu. W badaniu zastosowano: autorski kwestionariusz, skalę CRIES, decybelomierz i stoper.

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**Wyniki**: Całkowita liczba wszystkich wykonanych procedur w grupie 10. noworodków wyniosła 622. Średnio na jednego noworodka przypadły 62 procedury. Średnia dobowa liczba procedur inwazyjnych wykonanych u jednego pacjenta wyniosła 6,6, natomiast interwencji skorelowanych z dotykiem 57,3. Średnie dobowe natężenie hałasu wyniosło 72,2 dB, średni całkowity czas dobowej ekspozycji na światło sztuczne wyniósł 87 min., przy średniej długości pojedynczego epizodu oświetlania 14,6 min. Średni poziom natężenia bólu u noworodków w stosunku do wybranych procedur inwazyjnych mieścił się w granicach od 5 do 7 pkt. w skali CRIES.

**Wnioski**: Oddziaływanie czynników traumatycznych na noworodki zaburza proces ich adaptacji oraz może negatywnie wpływać na dalszy rozwój ośrodkowego układu nerwowego, psychicznego i narządów percepcji sensorycznej.

**Słowa kluczowe**: czynniki traumatyczne, noworodek, wrodzona wada serca

## INTRODUCTION

Around 3500 neonates with congenital heart disease (CHD) are born in Poland annually. The mortality rate associated with CHD reaches an estimated 20% of all neonate deaths. Neonatal and infant periods are known to be the most critical ones for patients suffering from CHD [1]. Ductus-dependent CHD poses the greatest risk for these children's life. Specialist therapy focused on maintaining a stable health condition is closely related to a series of drastic procedures and, occasionally, to the necessity of a surgical intervention [2, 3]. Medical treatment intended for such patients requires that a special approach be adopted aimed at catering for all the needs that arise out of the specific characteristics of a given period of development as well as from neurobehavioral needs [4].

Despite the idea of limiting the impact of external factors on a neonatal patient, procedures related to the admission of a neonate to hospital and the child's stay in the cardiac ward are connected with their exposure to traumatic factors. Necessary and required activities of the therapeutic team usually result in a negative stimulation of the child. In said conditions, an inadequate or no response of the neonate may be observed as a reaction to the incoming stimuli. As a result of such negative stimulation, immeasurable damages may follow, which are hard to identify at this stage of development.

One of the most crucial factors that destabilize the condition of the neonates with CHD is noise. The exposure to noise interrupts both mental and physical balance and leads to changes in the circulatory, respiratory and nervous systems, disrupts sleep and constitutes a damaging factor for the hearing, especially accompanied by potential ototoxic factors [5,6]. Noise in the neonatal ward usually originates from the activities of the medical team, medical devices at work, acoustic conditions of a room as well as any activity related to everyday routines of the ward.

Light, in a similar manner to noise, constitutes a factor that disturbs sleep and other complex processes essential for the correct migration of neurons and brain development. Potential benefits and damages that result from various types of lighting (near darkness – ND) or continuous bright light – CBL) are not fully known. CBL triggers a stress reaction in neonates, which leads to hyperactivity, a decrease in the time of sleep as well as in changes of the heart rate. Limited exposure to light may also have an adverse impact on a premature or ill neonate. However, it is hard to foresee the advantages and disadvantages of the impact which the artificial light might have [7, 8].

Neonates with CHD require a special treatment which consists of employing therapeutic procedures closely linked to frequent handling. In modern wards, where state-of-the-art technologies are available, the frequency of direct contact with the patient is very high [9]. Handling, which results from the application of medical treatment, falls into the category of destructive factors for a neonate. Its side-effects comprise: anxiety, disorders of the sleep-wake cycle as well as a stress reaction in the form of irregularities in the heart and breathing rhythms. Very often this type of stimulation triggers neonates' defence reaction to human touch [9, 10]. However, touch itself may play a positive role in the neonate care if it is applied in the right manner and in proper conditions [11, 12].

Therapeutic activities administered in specialised care wards are also correlated with frequent pain stimulation of the neonatal patient with CHD. Hospitalized neonates are affected both by physical and psychological pain that arises out of their separation from their mother [13]. Endocrine disorders and intracranial bleeding are named as the consequences of pain perception. Long term consequences are connected with the 'pain memory'. The observation of an anxious neonate aimed at detecting the causes of such a condition proves a difficult task, as the anxiety may arise out of various sources [14].

In view of the foregoing, an attempt was undertaken aiming at assessing the exposure of neonates with ductus-dependent CHD to traumatic factors during the first 24 hours of hospitalization in the cardiac ward by means of evaluating the number of procedures related to touch, the number and duration of the episodes of exposure to artificial light, the intensity of the noise level as well as the number of invasive procedures performed on neonates, accompanied by a concurrent assessment of the noise level.

## MATERIAL AND METHODS

The research was conducted from 2013 to 2014 in the Department of Paediatric Cardiology of the University Children's Hospital in Krakow. The Director of the Hospital and the Head of the Department both granted their consent to the research.

The studied group comprised of 10 neonates of both genders, born at full term and in stable health. The weight of the patients in the studied group ranged from 2600 grams to 4160 grams, and the age spanned from the first 24 hours of life to 5 days. All these neonates were diagnosed with a duct-dependent heart disease. Each of the neonates received Prostin VR by means of continuous intravenous infusion, three of the patients were treated with parenteral nutrition, four with heparin and two with 10% glucose solution infusion; one patient received Corotrope. Moreover, three of the patients received oxygen via nasal prongs at the rate of 1 l/min. The neonates were being observed during their first 24 hours of hospitalization. Participation in the research was anonymous. Patients' inclusion criteria were based on medical diagnosis which confirmed the presence of ductus-dependent CHD without any concurrent diseases and the maturity of the neonates as well as their age, *i.e.*, from 1$^{st}$ to 5$^{th}$ day of life.

The research methods included observation of the neonates and their exposure to traumatic factors with the use of: author's questionnaire, a modified CRIES scale [15], stopper as well as VOLTGRAFT sound level meter (model: SL-50, the accuracy of measurements to ±3.5 dB with 1 kHz and the scope of detection of sound intensity from 40–130 dB).

The author's questionnaire contained data such as: gender, date of birth, date and hour of admission to hospital, anthropometric parameters, and variables correlated with a given group of traumatic procedures (handling, artificial light, noise, and pain). In order to assess the frequency of handling, certain procedures were selected closely related to care, diagnostic and therapeutic activities (weighing, dressing/undressing, bathing, changing, feeding, physical examinations, intravenous drug administration (IV), oral and per rectum drug administration (ROA), as well as other activities: measurement of the length and circumference, measurements of the body, change of the body positions, ECG, chest X-ray, and removal of a gastric tube or a catheter from the bladder).

The episodes of exposure to artificial light were counted and their duration was measured. In the morning, the neonate's exposure to light generated by a lamp during precise procedures that required a better lighting was assessed. During the night, the factors taken into account were the exposure to light and overall lighting of the rooms.

The assessment of the number and impact of invasive procedures on the pain perception of the patient was carried out directly upon the procedure completion. The following procedures were taken into account: drawing of capillary and venous blood, insertion of a peripheral venous line or gastric tube, suctioning of mucus from the nasopharyngeal cavity.

The pain level intensity was measured against the CRIES scale. Every patient underwent the procedure of drawing of capillary and venous blood. The insertion of a peripheral venous line was performed with eight neonates, while the insertion of a gastric tube with three patients, which provides a very limited feedback as far as the average pain level intensity values are concerned in the case of these both procedures. Suctioning of mucus from the nasopharyngeal cavity was a required procedure in the first 24 hours of hospitalization with one neonate, which provides the picture of pain perception only for that one specific patient, without the possibility of finding a mean value.

The assessment of noise was made at constant times and linked to intensification of therapeutic activities, *i.e.*, at the following hours: 4:00 a.m., 8:00 a.m., 12:00 p.m., 04:00 p.m., 08:00 p.m., and 12:00 a.m. The measurements were always taken in the central spot of the neonatal room.

Due to clinical specifications of the patients, the requirement of CRIES scale, which stipulates maintaining SpO2>95%, was amended to the SpO2 values ranging from 85% to 95% with oxygen flow rate of <2 l/min or >2 l/min, which are compliant with the above point system. Also the pulse and arterial blood pressure parameters were modified in such a way so that they could refer only to the heart rate. At the same time, 'breath' parameter that

contains 'same or lower frequency' – 0 points; <20% – 1 point; and >20% – 2 points is an added value. The general scale falls within the brackets from 0 points to 12 points, where 0 is equivalent to no pain and 12 means the pain of the highest intensity.

## RESULTS

Neonates within the first 24 hours of hospitalization endured 62 procedures on average (the highest number of procedures was 77, the lowest – 61). The total number of all procedures in the studied group amounted to 622.

### The assessment of exposure to handling

On a daily basis neonates on average underwent 57 procedures correlated with handling (the highest number – 63, the lowest – 48). The assessment performed during the day, *i.e.*, from 07:00 a.m. to 07:00 p.m., showed the following values: the mean number – 39 (the highest number: 44, the lowest number – 33); night-time values were on average at 18 (the highest number: 23, the lowest number – 14).

The procedures that were the subject of the assessment and were correlated with handling included changing nappies, performed, on average, 11 times a day. The mean numerical value of the remaining procedures is presented in Figure 1.

### The assessment of exposure to artificial light

Neonates within the first 24 hours of hospitalization endured direct exposure to artificial light 6 times on average (the highest number – 9, the lowest number – 3).

During the day, patients undergoing examination were, on average, directly exposed to light 2 times (the highest number – 4 times, the lowest – once a day). During night-time they were, on average, subjected to exposure to artificial light on 3 occasions (the highest number – 5 times, the lowest – 2 times).

The mean duration of a one-time episode of direct exposure to light averaged at 14.6 minutes (with the longest time value of a one-time exposure – 30 minutes, the shortest – 5 minutes).

The total duration of direct exposure to artificial light per day on average amounted to 87 minutes (the longest total time of direct exposure per 24-hour period – 125 minutes, the shortest – 40 minutes).

The mean values of complete duration of direct exposure to artificial light per day amounted to 31 minutes (the longest complete time of direct exposure per 24-hour period – 60 minutes, the shortest – 10 minutes). The observations at night-time brought mean values of complete duration of direct exposure to artificial light per day of 56 minutes (the longest time – 80 minutes, the shortest – 30 minutes).

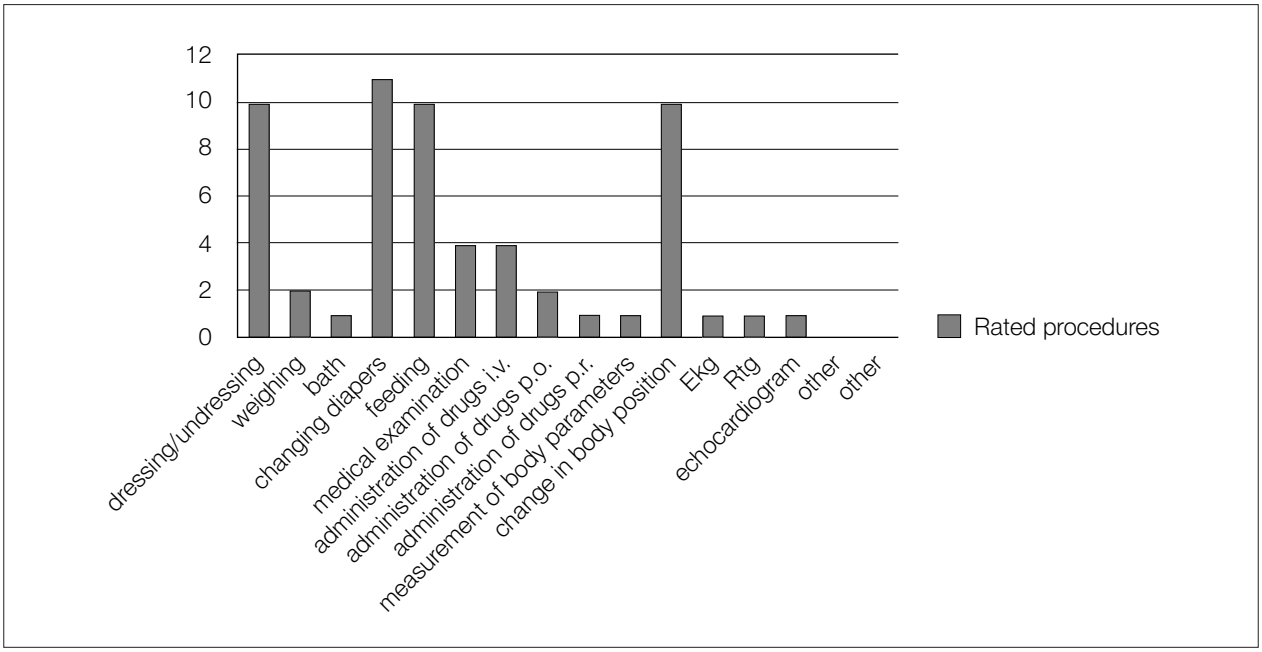


Fig. 1. The average number of invasive procedures performed in the first day of hospitalization
Ryc. 1. Średnia dobowa liczba wykonywanych procedur w pierwszej dobie hospitalizacji

### The assessment of noise level

Neonates in the first 24 hours of hospitalization were exposed to the average level of noise of 72.2 dB. The highest mean value noted, *i.e.*, the result of the mean value calculated from the noise level measured at certain determined measurement times during the day, was 79 dB, while the lowest mean value of the noise level reached 65.9 dB. Table I presents mean noise levels at the measurement times.

Table I. The average level of noise
Tabela I. Średnie natężenie hałasu

| The noise level [dB] | Measuring time | | | | | |
|---|---|---|---|---|---|---|
| | 8.00 am | 12.00 noon | 4.00 pm | 8.00 pm | 12.00 at night | 4.00 am |
| Medium | 80.5 | 73.4 | 69.3 | 70.4 | 63.5 | 62 |
| Maximum | 85 | 80 | 80 | 84 | 83.7 | 79 |
| The lowest | 71 | 65 | 60 | 53 | 47 | 48 |

### The assessment of continuous and uninterrupted sleep of neonates during a 24-hour period

The mean sleeping time per 24-hour period amounted to 17.23 hours (the shortest noted time was 16.5 hours, the longest – 18.5 hours). Neonate's sleep was interrupted on average by 33 procedures per day (the shortest noted time was 16.5 hours, while the longest – 18.5 hours). Neonates underwent 35 procedures on average in half-awake state (the highest number of procedures was 41, the lowest – 31).

### The assessment of the number of invasive procedures in the first 24 hours of hospitalization

Neonates within the first 24 hours of hospitalization were exposed to 6.6 7 procedures on average (the highest recorded number – 10, the lowest – 3). The number of procedures performed during the day was higher (the highest number was 9, the lowest – 3) than the number of procedures performed at night (with the highest number being 2).

### The assessment of neonates' pain level according to the CRIES scale

The mean pain level directly after drawing of capillary blood levelled at 4.7≈5, while after venous blood drawing it reached 6. The insertion of the peripheral line generated a mean level of pain perception at 5.7≈6. The insertion of a gastric tube, which took place in the case of three of the observed neonates, resulted in pain levels of the mean value of 5.6≈6. Suctioning of mucus from the nasopharyngeal cavity, which took place twice with the same neonate, generated a pain reaction equal to 7 points (Figure 2).

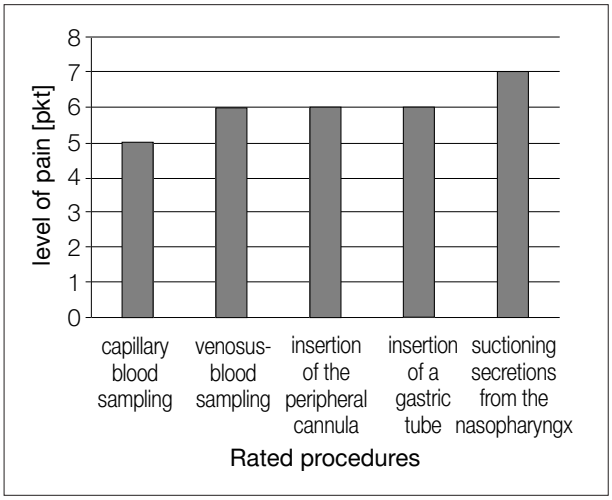


Fig. 2. The average level of pain intensity in newborns during invasive procedures
Ryc. 2. Średni poziom natężenia bólu podczas wykonywania inwazyjnych procedur

### The assessment of individual variables according to the CRIES scale directly after drawing of capillary blood

In the first 24 hours of hospitalization capillary blood was drawn from all the observed neonates. With respect to the parameters comprised in the modified scale of pain assessment, this procedure resulted in loud crying among the whole studied group. The oxygen therapy (in order to achieve blood oxygen saturation level of 85–95%) at a flow rate of 2 litres per minute was required in case of three patients, while seven of them did not require oxygen therapy.

Heart rate increased by the value of <20% with respect to the output level in 10 neonates. As far as the expressions of pain were assessed, all of the observed patients displayed a grimace of pain. After completion of the procedure, five neonates were often in the state of wakefulness, while the remaining five went back to sleep. With all the neonates an increase in the breathing rate by the value of <20% with respect to the output parameters was observed.

### The assessment of individual variables according to the CRIES scale directly after drawing of venous blood

Drawing of venous blood in the first 24 hours of hospitalization was performed with all neonates and in all cases it resulted in loud crying. In case of four patients there was no need for oxygen therapy,

four neonates required administration of oxygen at the flow rate of 2 litres per minute, in case of two patients oxygen therapy was started at the flow rate of 2 litres per minute. Directly after completion of the procedure, the pulse rate of six patients increased in value by <20% with respect to the output level, while four patients displayed an increase in value by <20% in the pulse rate with respect to the pre-procedure parameters.

Facial pain expression of the neonate directly after drawing of blood did not appear with one neonate, while with the remaining two the grimace was present. The procedure contributed to inducing the state of wakefulness with four patients, while with six neonates it did not invoke the described state. The breath rate after the procedure increased by the value of <20% with respect to the output level with six patients, and in case of four patients by the value of <20% with respect to the pre-procedure level.

### The assessment of individual variables according to the CRIES scale directly after insertion of peripheral venous line

The insertion procedures for peripheral venous line were performed with eight studied neonates. The procedure resulted in loud crying with all the patients. In case of three neonates, there was no need for starting oxygen therapy, while with the other five oxygen therapy was administered at the flow rate of 2 litres per minute. Directly after the procedure, the pulse rate increased with six neonates by the value of <20% when compared with the output values, while with two it raised in value by <20% when compared to the pre-procedure level.

Facial pain expression showed in every patient in the form of a grimace. After the procedure, six of the neonates remained in the state of wakefulness, while two went back to sleep. The breath rate after the procedure increased by the value of <20% with respect to the output level with seven patients and in case of one patient by the value of <20% when compared to the pre-procedure level.

### The assessment of individual variables according to the CRIES scale directly after insertion of gastric tube

The insertion of gastric tube in the first 24 hours of hospitalization was a requirement with three out of ten observed neonates. The procedure triggered very loud crying with all the subjects. In case of one neonate there was no need for starting oxygen therapy, while with three oxygen therapy was administered at the flow rate of 2 litres per minute. Directly after completion of the procedure, the pulse rate with two patients increased in value by <20% with respect to the output level, while one patient displayed the pulse rate increase by <20% when compared to the pre-procedure parameters.

Facial pain expression in the form of a grimace showed directly after insertion of the gastric tube with every patient. The procedure contributed to inducing the state of wakefulness with two patients, while with one neonate it did not invoke the said state. The breath rate after the procedure increased by the value of <20% with respect to the output level with all patients.

### The assessment of individual variables according to the CRIES scale directly after suctioning of the mucus from the nasopharyngeal cavity

The procedure of suctioning the mucus from the nasopharyngeal cavity was performed with only one neonate. It triggered loud crying with the patient and resulted in the need for oxygen therapy at the flow rate of 2 litres per minute. As a result, the pulse rate increased by the value of <20% with respect to the output level. The pain was expressed in the form of a grimace. After the procedure, the neonate remained in the state of wakefulness. The breath rate after the procedure increased by the value of <20% with respect to the pre-procedure level.

## DISCUSSION

Currently more and more evidence shows that repeated stress impulses in the neonatal period of life may result in long-term consequences for the neonate's development [16]. The author's own research documented the fact that in the first 24 hours of hospitalization a neonate with critical CHD and in a stable state endures a significant number of procedures of different nature which disrupt his wake-sleep cycle to the detriment of his well-being. However, in view of the necessary diagnostic and therapeutic activities, the said procedures must be performed. In case of invasive procedures performed on the measurement day, the results obtained are lower when compared with those gathered by Simonds [17]. However, the author stressed in her report that performance of the largest number of invasive procedures for the most part falls within the first 24 hours of hospitalization. The therapeutic team should undertake special efforts in order to reduce their frequency, *e.g.*, by grouping the procedures in such a manner, so as to enable drawing blood for multiple tests.

The present study also provided an analysis of the pain perception of neonates with respect to certain invasive procedures. Similar studies were carried out by, *inter alia*, Newnham *et al*. [16] and Simons [17]. The results of this research as compared to the above mentioned observations provided similar values, despite the fact that the group differed with respect to clinical diagnosis. Due to the fact that invasive procedures trigger a pain reaction with neonates, which carries long-lasting consequences, the actions undertaken for the benefit of the patients with CHD should not be limited to lowering their stress levels, but most of all, should foster conditions favourable for patients' return to the pre-procedure state. Among the methods that help reduce pain perception are: positioning, non-nutritive sucking, and exposure to acoustic and olfactory sensations that come from the mother or saccharin analgesia.

Moreover, the research has shown that the number of procedures correlated with handling is high. Thus, one may assume that it constitutes a significant factor that violates the biological, psychological and emotional integrity of the neonate. Other authors confirm the fact that neonates are subjected to traumatic handling on unnecessarily frequent occasions [18,19]. On the basis of the observations carried out as well as from the researchers' own experience, it must be noted that in certain cases some invasive procedures do not result in interruption of neonate's sleep. Such situations take place if the patient is physically exhausted because of numerous previous procedures or if the patient is in the state of deep sleep with a significant drop in activity resulting from a poor health condition. These situations must be a cause for greatest concern.

In this research the measurements of noise levels taken during the 24-hour period at a cardiac ward were higher than those gathered by Chen *et al*. [20]. Other authors also draw attention to the high noise levels in neonatal wards [5, 21–24]. Taking into account the scientific data gathered in this field as well as the therapeutic teams' experience, activities that lower the scope of noise levels and their adverse impact on the patients' bodies must be undertaken.

Aside from environmental factors mentioned above that have an influence on neonates with CHD, the measurements of both the number and duration of the exposure to artificial light were performed. It was shown that during a 24-hour period neonates were subjected to artificially generated light on several occasions and that the total mean time of such exposure was significant. Scientific publications provide hardly any comparative data that may be juxtaposed with the results obtained, as other researchers assessed the intensity of light in different conditions or investigated different relationships [25–27]. None of the available studies, however, was conducted in a group of neonates with ductus-dependent CHD.

The data obtained from the authors' study present only an outline of the problem and in view of the fact that the studied group was small, they may not be considered as sufficiently solid. In order to acquire more reliable data, research on a larger group of patients and over a longer period of time should be conducted. The importance of the problem should be pointed out to medical teams, who ought to pay closer attention to the threats that CHD neonates are exposed to because of the hospital environment, and actions aimed at limiting their scope and consequences should be undertaken.

The analysis of national and international reference sources revealed the absence of any current research that discusses the problems of negative stimulation and its influence on the health condition of neonates at a cardiac ward.

## CONCLUSIONS

1. Neonates with ductus-dependent CHD in the first 24 hours of hospitalization endure a variety of activities that are highly traumatic or which generate an intense pain reaction.
2. The impact of noise, pain and artificial lighting over the neonates hospitalized in the cardiac ward is significant and may disrupt the process of adaptation, have an adverse impact on further development of central nervous system, perception and sense organs as well as disturb psychological and emotional health of the patients.

**Conflict of interests:**
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*Brak jakichkolwiek źródeł finansowania, brak konfliktu interesów*

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