Sudden unexpected infant death syndrome and the temperature: a review of literature

(Zespół nagłej śmierci niemowląt i temperatura – przegląd piśmiennictwa)

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Abstract – Sudden unexpected infant death syndrome (SUIDS) is one of the leading causes of death in cases of infants aged 0-12 months. Modern theories claim SUIDS is triggered by the synergistic effect of environmental, genetic, and metabolic factors which do not cause SUIDS itself directly, but make the infant more vulnerable. One of the potential trigger factors of SUIDS occurrence is high temperature (including heat waves). Analysis of collected literature does not answer clearly if heat waves can have a significant impact on the occurrence of sudden unexpected infant death syndrome. More research is needed to prove or finally reject the hypothesis of the impact of the outdoor and indoor temperature on sudden unexpected infant death syndrome.

Key words - Sudden Unexpected Infant Death Syndrome (SUIDS), temperature, heat waves.

Streszczenie – Zespół nagłej śmierci niemowląt (SUIDS) jest jedną z najważniejszych przyczyn zgonów niemowląt w wieku 0-12 miesięcy. Współczesne teorie próbują wyjaśnić SUIDS przez synergistyczny efekt działania czynników środowiskowych, genetycznych i metabolicznych, które same w sobie nie powodują nagłej śmierci niemowląt, ale czynią niemowlęta bardziej wrażliwymi. Jednym z potencjalnych czynników wyzwalających SUIDS jest czynnik podwyższonej temperatury (w tym fale upałów). Analiza zebranych źródeł literatury nie pozwala w sposób jednoznaczny odpowiedzieć na pytanie czy czynnik fali upałów może mieć znaczący wpływ na pojawienie się zespołu nagłej śmierci niemowląt. Przegląd dostępnego piśmiennictwa wykazał potrzebę kontynuacji badań wokół SUIDS, w celu potwierdzenia lub odrzucenia ostatecznej hipotezy o wpływie zewnętrznej temperatury i temperatury w pomieszczeniu na pojawienie się zespoł nagłej śmierci niemowląt.

Słowa kluczowe - zespół nagłej śmierci niemowląt, temperatura, fale upałów.

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I. INTRODUCTION

The death of a child is probably the most tragic event in parents’ lives. This tragedy is even worse if the child dies suddenly in his or her sleep, apparently for no reason [1]. Sudden unexpected infant death syndrome (SUIDS) is one of the leading causes of death among babies between 1 and 12 months of age. Most babies who die of SUIDS are between the ages of 2 and 4 months (up to 90% of all deaths) [2]. Baby boys are more vulnerable in comparison with baby girls [3]. This syndrome is sometimes called “crib death” or “cot death”, because it is associated with the timeframe when the baby is sleeping. Most SUIDS are reported as one of three types:

- sudden infant death syndrome (SIDS) – infant death cannot be explained after a complete autopsy, ex-
amination of the death scene, and a review of the clinical history;
• unknown cause – the sudden death of an infant is unexplained and does not meet the criteria for a diagnosis of SIDS;
• accidental suffocation and strangulation in bed (ASSB) – including suffocation by soft bedding, overlay, wedging or entrapment and strangulation.

SUIDS rates across the world are very diverse: the highest numbers are observed in the Western Hemisphere (0.45-0.7 babies per 1,000 live births), countries of Western Europe (0.4/1,000), and New Zealand. One of the lowest rates has been recorded in the Far East [4, 5]. Japan has one of the lowest infant mortality rates (fewer than 3 infants per 1,000 live births compared to 7 in the U.S.) and one of the lowest SUIDS rates in the world (0.1 babies per 1,000 live births compared to approximately 0.4 per 1,000 infants in the U.S.) [5]. Although SUIDS rates have declined in most of the world, in some countries they still remain at high levels. In the United States, due to national campaigns promoting proper sleep positions of infants, such as Safe to Sleep campaign led by Eurice Kennedy Shriver National Institute of Child Health and Human Development, SUIDS rates have decreased by more than 50% for the first ten years of the campaign (since 1994), but as of now they are still high. According to the CDC data, 3434 U.S infants died suddenly and unexpectedly in 2013. Sudden infant death syndrome rates declined considerably from 130.3 deaths per 100,000 live births in 1990 to 40 deaths per 100,000 live births in 2013. Unknown cause infant mortality rates remain the same while accidental suffocation and strangulation in bed started to increase in 1998 and reached the highest rate of 21 deaths per 100,000 live births in 2013 (http://www.cdc.gov/sids/data.htm). SUIDS continues to be an important cause of postneonatal mortality in the United States [5, 6, 7, 8]. The main aim of the article is to review the modern concepts of the occurrence of SUIDS with a particular emphasis on the influence of the temperature on this phenomenon.

II. MAIN HYPOTHESES ON SUDDEN UNEXPECTED INFANT DEATH SYNDROME

There are many hypotheses regarding the cause of sudden unexpected infant death syndrome. Researchers currently use the Triple-Risk Model for understanding the mechanism of SIDS deaths [2]. According to this model, there are three conditions that may lead to the death of an infant from SUIDS:
• vulnerable infant – multiple abnormalities in brain serotonergic systems make the baby more vulnerable for outside stressors;
• critical developmental period – during the first 6 months of life of the babies, some developmental changes appear (sleeping and waking patterns, variations in breathing, heart rate, blood pressure and body temperature) and they may destabilize the infant’s internal system in short-term or long-term perspective;
• outside stressors – such as stomach sleep position, overheating, passive tobacco smoking, an upper respiratory tract infection and other triggers may make the infant more vulnerable and decrease the chance to survive.

According to the Triple-Risk Model, all three elements must be present for a sudden infant death to occur. Factors increasing the risk of SUIDS occurrence should be divided into prenatal risks and postnatal risks (Fig. 1). Among crucial factors in occurring SUIDS one should admit the following: improper sleep position and bed sharing, heat stress, premature birth, infections (especially respiratory syncytial virus). Other studies linked SUIDS to inherited defects in serotonin transporter genes [9, 10].

Current theories explain SUIDS referring to a combination of environmental, genetic, and metabolic factors that do not cause the death of infants directly, but make them more vulnerable [11, 1]. Some pieces of evidence suggest that peculiarities of thermoregulatory capacity of infants increase the susceptibility to thermal stress and risk of sudden death [11].
According to the Intergovernmental Panel on Climate Change, global warming is one of the most dangerous climatic changes in the 21st century [12]. From 1910 until 2007, the global average temperature increased by 0.74°C and it is currently rising between 0.15 and 0.3°C per decade [13]. It means that the threshold for safe human existence will be exceeded during this century. Modern climate changes are one of the biggest global health threats of the 21st century [14], especially for pregnant women, the developing foetus and children [15, 16, 17]. Some possible diseases and complications for maternal and infants health related to climate changes are shown in Figure 2.

A number of publications proved that SUIDS could be connected with infant’s overheating through overwrapping, bundling and others [21]. Yet, there is a limited number of publications on the impact of outdoor temperature on SUIDS. According to the American Academy of Pediatrics Policy Statement on Global Climate Change and Children’s Health, the problem of the impact of outdoor temperature on vulnerable groups of the population (children and elderly people) is one of the urgent problems for modern society due to the actual climatic changes. Only one publication was found on the link between SUIDS and indoor temperature [22]. The results of the research showed that the thermal environment of the infant did not vary by indoor or outdoor temperature, but higher average values were observed in teenage mothers, infants who slept in an adult bed and infants with an illness. There was a tendency for the thermal environment of infants to be higher and more variable during winter, supporting previous hypotheses that

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**Figure 1. Factors increasing the risk of SUIDS [1]**

**Figure 2. Maternal and infant diseases and complications related to climatic change**

Infants are especially sensitive to extreme temperature of the environment due to their limited temperature regulation capacity [18]. Some studies found that extreme temperatures, both low and high, resulted in preterm births, stillbirths, and low birth weight [19]. According to P. E. Sheffield and P. J. Landrigan, modern heat-related climate change results in pregnancy complications, poor birth outcomes, renal effects and in diminished school performance [20].

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III. SUDDEN UNEXPECTED INFANT DEATH SYNDROME AND THE TEMPERATURE

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paradoxical overheating may occur in some infants during winter.

The studies on the relationship between climatic temperature and SUIDS incidence were performed predominantly in countries without extreme temperature variations, such as Great Britain, Australia (Tasmania), and New Zealand [23, 24, 25, 26]. Such research associated increased SUIDS incidence with colder outdoor temperatures and parent’s efforts to increase indoor temperature and overwrapping infants. The impact of high temperature on population mortality was studied in cases of the elderly [15, 27, 28, 29], but relatively small amount of publications is dedicated to infants. Few studies investigated an association between high temperature and SUIDS incidences and reported no association between those two notions [30, 31]. Studies of the researchers from Canada, on the contrary, showed that high ambient temperature may be a risk factor for SUIDS, especially after 3 months after birth [32]. Nathalie Auger and her team analysed possible associations between high temperature and SUIDS incidences in metropolitan Montreal, Quebec (Canada) for the period of 1980-2010. Their research proved that maximum daily temperatures of 29°C or higher some days were associated with 2.78 times greater cases of sudden infant deaths in comparison with the temperature of 20°C [32]. The relationship between higher temperatures and SUIDS was stronger for babies aged 3-12 months compared with those aged 1-2 months, with odds ratios of 3.90 and 1.73 respectively, for deaths on days with maximum temperatures of 29°C versus 20°C. But that study has limitations. According to De-Kun Li, a senior research scientist at the Kaiser Permanente Northern California Division of Research, although the authors measured outdoor temperatures, they didn’t measure the actual temperature of the room in which the baby slept. According to him “plenty of SIDS deaths occur in winter when babies are dressed too warmly, and the same could occur during heat waves when houses may be air-conditioned to the point of chilliness” [33]. A cross-cultural study found comparatively weak relationships between climatic temperature and SUIDS incidence in the United States [34, 30]. Retrospective studies of Joshua R. Scheers-Masters research team was conducted for each of 454 counties in 4 states (Arkansas, Georgia, Kansas and Missouri) from May to September, 1980. According to their studies, the heat stress associated with prone sleep positions and high outdoor temperatures do not have a significant role in SUIDS occurrence. There are confounding factors in interpreting SUIDS, which contributed to death through other mechanisms such as rebreathing of expired air causing asphyxiation. Thermal theory draws a sharp distinction between SUIDS resulting from heat stress and death attributable to extreme hyperthermia leading to heat stroke [35, 36]. It has been suggested that congenital or anatomic abnormalities in brainstem centres regulating respiratory or cardiovascular stability render infants susceptible to death resulting from heat stress [37]. Study of infants hospitalization due to heat stress showed that 68% of parents were unaware of the need for increased fluid intake by their infants during hot weather [38]. The practice of leaving sleeping infants in parked cars is also a frequent cause of heat-related morbidity and mortality [30, 39, 40]. Some studies indicated that the majority of the infants, especially infants in low-income households, did not have access to air conditioning (in 1980 more than 80% households with infants in the lower one-third socioeconomic group did not have air conditioning or fans [41, 42]. In addition to that, it was proved that low-income, urban and African American populations are at highest risk for heat stroke because of the combination of different factors, among which one should mention the following [43, 44]:

- “heat-island” effect that increases both indoor and outdoor temperatures;
- non-standard housing;
- poor ventilation;
- poor access to air conditioning.

IV. CONCLUSION

Sudden unexpected infant death syndrome is one of the leading causes of death for infants aged 0-12 months. According to De-Kun Li, a senior researcher at the Kaiser Permanente Northern California Division of Research (USA), “understanding causes for SIDS remains a work in progress. It’s very hard to study” [33, p. A 185]. Modern theories explain SUIDS through the synergistic effect of environmental, genetic and metabolic factors which do not cause SUIDS themselves, but make the infant more vulnerable. Analysis of collected literature does not answer clearly if heat waves can have a significant impact on the occurrence of sudden unexpected infant death syndrome. More research is needed to prove or finally reject the hypothesis of the impact of the outdoor and indoor temperature on sudden unexpected infant death syndrome. But taking into consideration destructive influence of modern climate changes at birth outcomes and infant health, proved by many researchers, special medical and governmental strategies directed at protection of the infant during periods of
high ambient temperatures should be developed and implem-mented.

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V. REFERENCES