

REVIEW / PRACA POGLĄDOWA

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THE IMPORTANCE OF TICK-BORNE DISEASES IN PUBLIC HEALTH**ZNACZENIE CHORÓB ODKLESZCZOWYCH W ZDROWIU PUBLICZNYM**

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S u m m a r y

Ticks are common vectors of pathogenic microorganisms causing contagious diseases. The aim of this paper is to draw attention of family physicians to the necessity to take into account various infections and contagions related to ticks in diagnostic considerations.

Tick bite can lead to a simultaneous infection by multiple pathogens. These arachnids are vectors among Lyme disease, tick-borne encephalitis and meningitis, Q fever, tularemia, rickettsiosis, anaplasmosis (ehrlichiosis) and

babesiosis. Monitoring of tick vectors and the pathogens they transmit, within the scope of epidemiological surveillance, is an important tool for better prevention and control of tick-borne diseases. Despite available options concerning the appropriate technique of tick removal and disagreement as to the most effective of these recommendations, there is consensus on the importance of their removal as soon as possible.

S t r e s z c z e n i e

Kleszcze są powszechnymi przenosicielami patogenów wywołujących choroby zakaźne. Celem pracy jest zwrócenie uwagi lekarzy rodzinnych na konieczność uwzględnienia w rozważaniach diagnostycznych ryzyka występowania różnych infekcji i zarażeń związanych z kleszczami.

Pogryzienie przez kleszcze może prowadzić do jednoczesnego zakażenia wieloma patogenami. Pajęczaki te są wektorami m.in.: czynników etiologicznych wywołujących boreliozę, kleszczowe zapalenie mózgu i opon mózgowo-

rdzeniowych, gorączkę Q, tularemię, rickettsjozę, anaplazmozę (erlichiozę) i babeszjozę. Nadzór epidemiologiczny w zakresie monitorowania kleszczy i patogenów które przenoszą jest ważnym narzędziem dla lepszego zapobiegania i kontrolowania chorób odkleszczowych. Pomimo dostępności różnych opcji dotyczących doboru odpowiedniej techniki usuwania kleszczy i rozbieżności co do rekomendacji najskuteczniejszej z nich, istnieje zgodność co do znaczenia jak najszybszego ich usuwania.

Key words: ticks, tick-borne diseases, *Ixodes ricinus*

Słowa kluczowe: kleszcze, choroby odkleszczowe, *Ixodes ricinus*

BIOLOGY OF TICKS:

Ticks are temporary, obligate blood-sucking ectoparasites of human and other terrestrial vertebrates. This group consists of more than 800 species; however, only 30

of them feed on humans [1]. They are arthropods that belong to the class of *Arachnida* and, with other mites, comprise the subclass *Acari* [2]. Ticks are classified in the suborder *Ixodida* (order *Parasitiformes*) and they are unique among *Acari* in possessing large body size (2-30 mm) and specialized

mouthparts [3]. The two main groups of ticks are the hard ticks (*Ixodidae* family) and the soft ticks (*Argasidae* family). The hard ticks take their name from a tough cuticle, in contrary to the soft ticks, whose cuticle is of a pliable leathery kind. The hard ticks are more common, harder to remove and more likely to transmit disease than the soft ticks [1]. All ticks are characterized by possessing four pairs of walking legs, but they have low mobility and their dispersal is mainly linked to transportation by host animals during infestation, notably by highly mobile mammals or birds. The body of these arachnids consists of gnathosoma and idiosoma, and they lack of eyes. Within the *Ixodidae* family the idiosoma of the male body is covered with the dorsal shield, which in females covers only a half of dorsal part and the rest is covered with the stretch chitin shell. That is why the body of female can grow by several folds after feeding. The mouthparts of ticks [Fig. 1.] form a scissors-shape two-pronged, chelicerae with centrally located hypostom, used for penetrating skin of the host [2].



Fig. 1. Mouth-part of *Ixodes ricinus*, magnification $\times 100$ (photo from the collection of The Chair of Medical Biology, Collegium Medicum NCU)

Fig. 1. Aparat gębowy *Ixodes ricinus*, powiększenie $\times 100$ (fotografia ze zbiorów własnych Katedry Biologii Medycznej, Collegium Medicum UMK)

Ticks are second to mosquitoes vectors of diseases to humans [4]. Diseases transmitted by ticks occur as natural foci and their range is equivalent to the geographical spread of certain species of ticks [5]. In Europe the most common tick is *Ixodes ricinus*, which most predominantly infects humans [6]. In Poland, the most important in the epidemiology of tick-borne diseases are two species of ticks: *Ixodes ricinus* (a representative of hard-ticks) and *Dermacentor reticulatus* (a representative of soft ticks) [7]. *Ixodes ricinus* occurs widely in deciduous and mixed forests (more rare in coniferous forests), also in municipal parks, allotment gardens and on lawns [5]. It is responsible for the transmission of pathogens of about 20 diseases [8]. This species is characterized by a seasonal activity attributable to the period from March to November. The largest activity is observed in May and June as well as in September and October [9]. *Dermacentor reticulatus* is widespread not only in Poland, but also in the countries of Eastern Europe. Typical habitats of this species are meadows and mid-forest clearings and the largest number of bites are reported from June to August [6].

The status, distribution and abundance of the main tick species are implicit requirements for the risk assessment of tick-borne infections of pathogen in humans. The risk of attack is increased while staying for occupational or recreational

purposes in tick habitats during their seasonal activity [6]. Currently, individual aspects of tick activity as well as the distribution of risk areas suggest an influence of the climate [10]. Ticks are detected in their habitats by flagging method or by blanket dragging [11, 12]. Eastern and south-eastern Poland is the area of high risk of infections by tick-borne pathogens [6]. Yet, the knowledge of the residents of this area concerning the principles of tick prophylaxis is insufficient. The high density of ticks in recreational and agricultural areas demands that residents should pay more attention to consequences of tick parasitism and the medical services should better promote the methods of prevention [6]. It should be emphasized that people who have undergone tick removal should be monitored up to 30 days for signs and symptoms of tick-borne diseases such as occurrence of a skin lesion at the site of the tick bite or a temperature higher than 38°C [1].



Fig. 2. *Ixodes ricinus* – larva, magnification $\times 100$ (photo from the collection of The Chair of Medical Biology, Collegium Medicum NCU)

Fig. 2. *Ixodes ricinus* – larwa, powiększenie $\times 100$ (fotografia ze zbiorów własnych Katedry Biologii Medycznej, Collegium Medicum UMK)

In the lifecycle of ticks, there is a tendency for the 3 developmental stages of ticks to feed on different kinds of host [8, 10]. Larvae [Fig. 2.] feed on animals of all sizes, nymphs mainly on medium-sized to large hosts and adults [Fig. 3.] are limited to medium-sized and large hosts [10]. Human can be attacked by all stages of ticks [13]. Females after drinking a large amount of blood drop off the host and fall to the leaf litter. A long feeding time is particularly important for pathogens, which may multiply in the intestinal epithelial cells and spread with the lymph throughout the body of ticks. The pathogens are carried with lymph to the salivary gland cells and then ticks transmit them to the host through the process of feeding. Anti-inflammatory, lytic, anticoagulant and immunosuppressive activity of the components of tick saliva, fundamentally important for the physiology of those blood-feeding arthropods, naturally facilitates transmission of pathogenic microorganisms and accelerates spreading them from the site of penetration into the host's tissues [12]. Ticks are vectors of several diseases of human for example tick-borne encephalitis and meningitis, Lyme disease, babesiosis, Q fever, tularemia, rickettsiosis and anaplasmosis (ehrlichiosis). Ticks are also the vectors of *Bartonella* bacteria [8, 9]. A significant increase in tick-borne diseases has raised concern about the safety of blood and its components [8]. The most preferred by ticks places of adult human skin are extremities and the abdomen [6]. Tick bites are manifested by the occurrence of variety of

acute or chronic skin lesions. Most common local symptom induced by components of *Ixodes ricinus* saliva is erythema appearing at the bite site. These local lesions are found in about 70% of patients. Another common lesion is pruritus, which is observed in about 50% of patients. Skin lesions and systematic symptoms may not be present in large percentage of patients bitten by ticks [6].

The purpose of this paper is to summarize the most important issues concerning tick parasitism aimed to draw attention of the medical care workers to the significance of various infections and contagions related to ticks in diagnostic consideration.

TICK-BORNE ENCEPHALITIS:

Over past decades, tick-borne encephalitis (TBE) has become a growing public concern in Eastern and Central Europe and in Asia. It is regarded as one of most important and life-threatening human infections of the central nervous system, causing annually thousands of cases [7, 10, 14, 15]. Since 1990, the increase in the incidence of TBE has been observed, probably due to the elevated number of infected vectors and their increased activity [7]. During past twenty years the number of reported cases of TBE in Poland has ranged from 100 to 250 cases per year [10]. The most important risk areas are located in the northeast of the country. In southern Poland and in Silesia, highly endemic areas were found around Opole and Stalowa Wola. There are also a few small areas in Poland where the virus appears to be rare [10]. The symptoms of human infection may be represented by meningitis (50% of patients), meningoencephalitis (40% of patients) and as meningoencephalomyelitis (10% of patients) [14].

TBE is caused by tick-borne encephalitis virus (TBEV) [10]. TBEV belongs to the family of *Flaviviridae* and occurs in 3 subtypes: the European virus (TBEV-Eu), the Far East virus (TBEV-Fe) and the Siberian virus (TBEV-Sib). TBEV-Eu is closely associated with *Ixodes ricinus*, while TBEV-Fe and TBEV-Sib with other species of hard ticks - *Ixodes persulcatus* [10]. In Poland TBEV is transmitted by *Ixodes ricinus* and *Dermacentor reticulatus* [7, 15]. Many domestic and wild mammals are known to be potential reservoirs of TBEV [15]. Cisak et al. [14] analysed almost two hundred of milk samples from cows, goats and sheep bred on the farms situated on territory of Lublin province. The highest prevalence of TBEV was observed in sheep milk (about 22%), followed by milk of goats (about 21%) and cows (about 11%) [14]. In another research, Cisak et al. [15] analysed serum samples from different cattle species (cows, heifers and bulls), boars and deer species from territory of Lublin province and Rzeszów province, and they detected TBEV antibodies and TBEV-RNA in milk samples [15]. It should be stressed here that despite of tick bites, human can be infected with TBEV orally by consumption of non-pasteurized milk or cheese produced from raw milk obtained from infected animals [10]. It has been experimentally demonstrated that TBEV can be isolated from the milk of goats for 5–25 days following infection and the infectivity survives in various milk products such as yoghurt, cheese and butter. TBEV is known to be stable for up to two hours in normal digestive juice at pH 1.49–1.80. Thus, the digestive tract seems to be an efficient route of infection what was confirmed in experiments with mice, which became infected after they had been fed orally with TBEV [16].

Tick-borne encephalitis may be effectively prevented by vaccination [10, 17]. The vaccine is especially indicated for persons inhabiting or visiting the endemic area of TBE who are likely to be exposed to tick bites (e.g. forestry workers) [10]. In Europe, two vaccines are licensed and widely used [17]. An analysis of the effectiveness of TBEV vaccines based on

European subtype strains revealed a high degree of protection, in range of 99% against the endemic TBEV strains [17].

LYME DISEASE:

Lyme disease (LD) or Lyme borreliosis (LB) is the most common tick-borne disease in Poland and in Europe. It is a multisystemic disease caused by spirochetes belonging to the *Borrelia burgdorferi* sensu lato (sl) complex. In Europe, these spirochetes are transmitted by *Ixodes ricinus* [18]. *B. burgdorferi* sl complex constitute a group of 15 different *Borrelia* species and among them 7 species like *B. burgdorferi* sensu strict (ss), *B. garinii*, *B. afzelii*, *B. valaisiana*, *B. lusitanae*, *B. spielmanii* and *B. bissettii* have been identified in the ticks in Europe [18]. Infection usually occurs when the ticks finish the feeding (not earlier than 24 hours after penetration into the skin), usually on the third day [19]. Considering the risk of the transmission of the pathogens in forestry workers, Cisak et al. [5] evaluated the exposure to infection with tick-borne pathogens. They based their results on epidemiological investigation and serological tests. The result of their study clearly indicated that the woodcutters and other workers of low category are at the greatest risk of tick bites and transmission of tick-borne pathogens, including *Borrelia burgdorferi* spirochetes [5]. Bartosik et al. [6] performed research in south-eastern Poland (Lublin Province) in areas of high agricultural and recreational value and they revealed a high rate of infection of *Ixodes ricinus* ticks with different pathogens. Furthermore, they found that the probability of infection with *Borrelia burgdorferi* spirochetes and tick-borne encephalitis virus is higher in humid mixed forests than in coniferous forests [6].

BABESIOSIS:

Babesiosis is a human disease caused by parasitic protozoa of the genus *Babesia*. This disease is an example of a world-wide emerging zoonosis [20]. The manifestation of babesiosis ranges from asymptomatic infection to malaria-like disease, resulting in severe hemolysis and occasionally death [11]. The disease is known to be especially dangerous for immunocompromised individuals [11]. *Babesia* spp. multiply in red blood cells by asynchronous binary fission, resulting in considerable pleomorphism [20]. Asymptomatic *Babesia* invasion in humans may persist for months or even years. In this form of disease the parasites may be transmitted during blood transfusion. Welc-Fałęciak et al. [11] reported that overall prevalence of *Babesia* spp. in *Ixodes ricinus* at Polish forests in years 2010–2013 was 1.6%. The study presented an increase in prevalence of *Babesia* in ticks from larvae to adults, what may confirm the hypothesis of trans-stadial maintenance of infections. The results of their study are consistent with data reported recently in other European countries and different regions of Poland. The increase in prevalence of human-pathogenic *Babesia* isolates in ticks fully justified regarding babesiosis as an emerging disease in Poland [11].

ANAPLASMOSIS:

Human granulocytic anaplasmosis (formerly known as ehrlichiosis) is a febrile illness, caused by *Anaplasma phagocytophilum* – Gram-negative intracellular bacterium [8]. Anaplasmosis is also an acute infection of different ruminants, equines and canines [8]. The principle vectors of these pathogens are ticks from the *Ixodes ricinus* complex [21]. The bacteria causing anaplasmosis has been detected in *Ixodidae* ticks in most European countries [22]. Vichová et al. [21] studied *Anaplasma* infections in ticks and reservoir hosts from Slovakia. They detected the presence of *A. phagocytophilum*

in a wide spectrum of tested animals and confirmed the undoubted importance of wild ungulates for its circulation in natural foci of Slovakia [21]. In Polish urban and suburban forests, the prevalence of this pathogen was about 14% in individually examined *I. ricinus* ticks (2.0% nymphs and 29.7% of adults), while in Slovak suburban forest, it was 8.3% in individually examined adults [22]. This pathogen infects granulocytes and alters gene expression of these cells, which leads to prolonging their lifetime [8]. In Poland only few incidents of infection of this pathogen have been described. Symptoms of anaplasmosis include fever, headache, muscle aches and joint pains. Sometimes hepatomegaly, splenomegaly and lymphadenopathy also occur. There are also some changes in blood morphology, expressed by neutropenia, lymphopenia and thrombocytopenia [8]. Anaplasmosis is still underdiagnosed and in many cases course of the disease is asymptomatic or oligosymptomatic [8].

BARTONELLOSIS:

Bartonellosis is caused by bacteria of the genus *Bartonella*, which belongs to the order of *Rickettsiales*. Infections with this gram-negative bacillus occur usually in people with weakened immune system, due to chronic debilitating diseases or in those receiving immunosuppressive therapy (i.e. at transplant recipients). After penetration into the human body, *Bartonella* adheres to epithelial cells, in particular to endothelium of blood vessels. These bacteria are transmitted by ticks, but also by fleas and lice that feed on blood of infected mammals. The reservoir of this pathogen may be domestic and wild animals, but these arthropods have a strict preference on both transmitted bacterial species and reservoirs. All developmental stages of *Ixodes* tick can transmit infection. Among the bacteria of the genus *Bartonella*, transmitted by ticks, the species of *B. quintana*, *B. hanselae*, *B. vinsonii* subsp. *arupensis* and *berkhoffii* can be found. All these species can cause infective endocarditis. *B. quintana* can additionally lead to trench fever, infective endocarditis and bacillary angiomatosis. *B. hanselae* may also result in cat scratch disease, bacillary angiomatosis, retinitis, bacteraemia, retinitis and optic neuritis, while *B. vinsonii* subsp. *arupensis* can cause bacteraemia and fever [23].

CO-INFECTIONS:

Tick bites can lead to a simultaneous infection by multiple pathogens (co-infection) [8]. Different pathogens in the same tick do not usually interface with each other because they usually occupy certain different organs, tissues or even cell structures. In some diseases such as anaplasmosis or babesiosis, pathogens are present in blood, while pathogens causing Lyme disease have a tropism for other body cells. It has been known that *I. ricinus* species can carry several different pathogens at the same time and not only simultaneous transmission of pathogen during the blood meal occur, but the host can also develop simultaneous clinical infections caused by different pathogens [10]. Co-infections have quite significant implications; it is assumed that they can be a cause of polymorphism of symptoms, more severe course of the disease or difficulties in the treatment and resistance to treatment [8].

TICK PARALYSIS:

Ticks are also reported to be responsible for a toxin-mediated acute flaccid paralysis. Unlike other tick-borne diseases, tick paralysis is not caused by infectious agents, but it is induced by a chemical substance that attaches the nervous

system. Neurotoxin is secreted by the salivary glands of over 40 species of ticks as they feed. After prolonged attachment, the engorged tick transmits the toxin to its host. The incidence of tick paralysis is unknown and it is relatively rare, but it can be fatal and the majority of cases occur in children [1].

TICK REMOVAL:

The crucial issue in the protection against tick-borne diseases is the proper removal of the ticks [1]. In fact, most of the ticks do not carry disease and not all bites lead to infection, but any tick found should be immediately removed. Tick's mouthpart [Fig. 3] during feeding is inserted into the skin hence removing can be very complicated.



Fig. 3. *Ixodes ricinus* – adult, magnification $\times 32$ (photo from the collection of The Chair of Medical Biology, Collegium Medicum NCU)

Fig. 3. *Ixodes ricinus* – postać dorosła, powiększenie $\times 32$ (fotografia ze zbiorów własnych Katedry Biologii Medycznej, Collegium Medicum UMK)

There are several techniques to remove ticks, but none of them is absolutely effective. The experimental evidences to support the most suggested strategies of tick removal are still lacking [1]. For tick removal, a wide range of tools can be applied, including chemicals and mechanical treatment [24]. There are commercially available devices like tick tool, tick twister, tick nipper, tick key, pro ticked off [1]. The methods like applying a hot match or smearing with petroleum jelly to facilitate the tick removal are not recommended. They are not effective; what is more, they can lead to increased risk of illness as they can provoke regurgitation and transmission pathogens to human body [1]. For the same reason, squeezing during mechanical removal should be avoided as well as burning, because any stress (like heat) might induce regurgitation and release of pathogens into the wound [1, 24]. Roupakias et al. [1] described in few steps the most commonly recommended and successful method of tick removal until now. They imply to grasp the tick as close to the skin as possible, using fine-point tweezers or forceps, then gently pull the tick straight out with steady pressure and afterwards to check the bite point for the presence of a tick-remnant in the skin [1]. According to Centers for Disease Control and Prevention (CDC) it is not appropriate to twist or jerk the tick because it could cause the mouth-parts break off which may remain in the skin [25]. If this happens, the mouth-part should be removed with tweezers. Ducher et al. [24] observed that rotation seems to require less force and though breaking of the hypostome was more frequent in this technique, the part left in the wound was shorter than after removal by pulling. They also remarked

that less time is needed to extract female tick when rotation is used [24]. After removing the tick, it is advised to thoroughly clean the bite area and hands with rubbing alcohol, an iodine scrub or soap and water [25]. Although the available options concerning the appropriate technique (i.e. pulling vs. twisting) and the importance of the hypostome remaining in the wound greatly diverge, there is a consensus regarding the importance of removing ticks as soon as possible [24].

PROTECTING AGAINST TICKS:

The main to understand the risk of tick-borne diseases is knowledge of the consequences resulting from contact with these arthropods. Studies about the methods of prevention of tick-borne diseases among individuals from the group of occupational risk were conducted in several scientific Polish and international centers [5]. Important elements for prevention of tick-borne disease is using protective clothing and repellents [5]. Cisak et al. [5] in their study show, that the use of repellents in investigated forestry workers was related to reduced number of ticks found on the body [5]. Ticks can be transferred home on clothing and pets, and then they to a host. Some practical activities, such as inspection of clothing and animals to detect ticks, and bathing after spending time in the yard may reduce the risk of tick-borne diseases [5]. If it is possible, a good solution is to tumble clothes in a dryer on high heat aimed to kill remaining ticks.

CONCLUSIONS:

Knowledge of the presence of pathogens, the rates of infection in ticks and hosts in different regions are crucial for assessment of risk ratio for human and may help to establish the surveillance and control programs for vector-transmitted pathogens. Monitoring of tick vectors and the pathogens they transmit, within the scope of epidemiological supervision, is an important tool of public health for better prevention and control of tick-borne diseases.

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