

UDK 616.98:579.834.114:616-089.81(477)

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Surgical or professional removal of ixodes ticks: evaluation of need and perception of necessity by Ukrainian population

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Paediatric Surgery(Ukraine).2023.1(78):17-24; doi 10.15574/PS.2023.78.17

For citation: Shkilna MI, Andreychyn MM, Zaporozhan SJ, Huk MT, Grytsyshyn LY, Tokarsky OS, Korda MM. (2023). Surgical or professional removal of ixodes ticks: evaluation of need and perception of necessity by Ukrainian population. Paediatric Surgery (Ukraine). 1(78): 17-24. doi: 10.15574/PS.2023.78.17.

Tick bites are becoming a significant problem in Ukraine among adults and children, which can get tick-borne diseases through visits to the woody areas. Different tick removal techniques are well known, but professional removal is preferred to avoid further complications.

Purpose – to analyze questionnaire performed among forestry workers of seven regions of Ukraine on correlation of professional tick removal with further medical complications and other factors, such as sex, number of bites, repellent use, skin self-inspection, awareness and age, and to review general recommendations and methods of tick removal, including professional / surgical ones.

Materials and methods. Answers of 670 persons (611 males and 59 females), who were bitten by ticks, were analyzed. All respondents were tested for Lyme borreliosis by the enzyme-linked immunosorbent assay specific IgM and IgG antibodies against *B. burgdorferi* method. Two by two contingency tables were built to analyze factors that may lead to the seeking of professional tick removal and to analyze consequences of self-removal. Pearson chi-squared tests at $p < 0.05$ and odds ratios with the confidence intervals ($\alpha = 95\%$) were calculated to test for association and its strength. Spearman correlation value ($p < 0.05$) between age and seeking of professional tick removal was calculated.

Results. Only 7.3% of forestry workers (7.0% males and 10.2% females) visited medical establishments to professionally remove attached ticks. Forestry workers with high awareness were more likely to seek professional help for tick removal ($p < 0.05$). Almost half (44.6%) of the forestry workers claimed to remove ticks with bare fingers, with 7.9% – by scratching away and 22.4% – by twisting out; 23.7% of all forestry workers used oil to suffocate ticks, all of which is not recommended. Only 32.2% of forestry workers used disinfectants after tick removal. The odds of Lyme borreliosis positive results among foresters who sought professional tick removal was 0.47 times of the odds among foresters, which did not seek.

Conclusions. To summarize, forestry workers and other sensitive population should be better educated regarding benefits of seeking professional tick removal. Moreover, seeking immediate professional medical help may also improve treatment of further medical complications in case of borrelia infection, as the doctor at the trauma center may explain symptoms of Lyme borreliosis and further sequence of actions for the patient. The surgical procedure for tick removal is described in literature, may decrease chances of tick-borne diseases spread, and should be considered for further implementation at Ukrainian medical establishments.

The research was carried out in accordance with the principles of the Helsinki Declaration. The study protocol was approved by the Local Ethics Committee of the participating institution. The informed consent of the patient was obtained for conducting the studies.

No conflict of interests was declared by the authors.

Keywords: ticks, removal methods, forestry workers, awareness.

Оригінальні дослідження. Загальна хірургія

Хірургічне або професійне видалення іксодових кліщів: оцінка потреби та сприйняття необхідності населенням України**М.І. Шкільна, М.А. Андрейчин, С.Й. Запорожан, М.Т. Гук, Л.Є. Грицишин, О.С. Токарський, М.М. Корда**

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Значною проблемою в Україні серед дорослих і дітей стають укуси кліщів, які є векторами багатьох інфекційних захворювань. Різні методи видалення кліщів добре відомі, проте, щоб уникнути подальших ускладнень, перевагу надають професійному видаленню.

Мета – проаналізувати дані анкетування працівників лісового господарства семи регіонів України щодо методів видалення, а також стосовно кореляції між вибором професійного видалення кліщів і подальшими медичними ускладненнями та іншими факторами, наприклад, обізнаністю, статтю людини, кількістю укусів, використанням репелентів, самоперевіркою шкіри, віком; розглянути методи видалення кліщів, у тому числі професійні/хірургічні.

Матеріали та методи. Проаналізовано дані анкетування 670 осіб (611 чоловіків і 59 жінок), які зазнали укусів кліщів. Усіх респондентів проскринінговано на Лайм-бореліоз методом імуноферментного аналізу для визначення специфічних IgM та IgG до *B. burgdorferi*. Для аналізу факторів, які можуть призвести до звернення по професійне видалення кліщів, і для аналізу наслідків самостійного видалення кліщів створено 2×2 таблиці непередбачуваності. Критерії хі-квадрат Пірсона ($p < 0,05$) і відношення шансів із довірчими інтервалами ($\alpha = 95\%$) розраховано для перевірки асоціацій та їхніх статистичних значущостей. Розраховано значення кореляції Спірмена ($p < 0,05$) між віком і зверненням по професійне видалення кліщів.

Результати. Лише 7,3% працівників лісових господарств (7,0% чоловіків і 10,2% жінок) відвідували медичні заклади для професійного видалення кліщів. Високий рівень обізнаності сприяв частішому зверненню по професійну допомогу для видалення кліщів ($p < 0,05$). Майже половина (44,6%) опитаних стверджували, що кліщів видаляли голими пальцями, 7,9% – зішкрябуванням, 22,4% – викручуванням; 23,7% усіх опитаних використовували олію для удушення кліщів, усі ці методи не рекомендуються. Лише 32,2% опитаних після видалення кліщів використовували дезінфікуючі засоби. Відношення шансів щодо позитивного скринінгового результату Лайм-бореліозу в лісників, які шукали професійного видалення кліщів, становило 0,47 разів відношення шансів серед лісників, які самостійно їх видаляли.

Висновки. Працівники лісових господарств та інші чутливі верстви населення повинні бути краще обізнані щодо переваг звернення по професійне видалення кліщів. Крім того, негайне звернення по професійну медичну допомогу також може поліпшити лікування подальших медичних ускладнень у разі зараження бореліями. Хірургічна процедура видалення кліщів описана в літературі, вона може зменшити ймовірність поширення кліщових захворювань і повинна бути розглянута для подальшого впровадження в медичних закладах України.

Дослідження виконано відповідно до принципів Гельсінської декларації. Протокол дослідження ухвалено Локальним етичним комітетом зазначеної в роботі установи. На проведення досліджень отримано інформовану згоду пацієнтів.

Автори заявляють про відсутність конфлікту інтересів.

Ключові слова: кліщі, методи видалення, працівники лісового господарства, обізнаність.

Introduction

Ixodes is a genus of hard-bodied ticks, which include important disease vectors for tick-borne diseases of animals and humans. Tick-borne diseases are caused by different infectious agents, such as borrelia, rickettsia, and other bacteria, as well as viruses and protozoa, transmitted through tick bites [11,24]. While *Ixodes scapularis* is the primary species of concern in the USA, *Ixodes ricinus* ticks, which are present in Europe, may spread the pathogens more quickly [30].

Lyme borreliosis (LB) is the most common tick-borne disease in Ukraine and is manifested by migratory ring-shaped erythema, fever, damage to the central and peripheral nervous system, heart and joints [26]. Cases of tick-borne LB were recorded in Ukraine since 1994 regardless of the region, however, the official statistics collection for the disease began later in 2000 [22] with an incidence value of 10.62 per 100,000 in 2019 among Ukrainian population [26].

Forestry workers belong to the population groups with a high risk of tick bites and the *Borrelia* infection [9,10]. The awareness of the forestry workers about

dangers associated with ticks [12] and their infection with *B. burgdorferi* has been studied in a number of European countries [12,28]. In Ukraine, similar studies were conducted only among a small number of forestry workers in Lviv region [31], as well as in Zhytomyr, Khmelnytskyi, Volyn, and Ternopil regions [1,3,25].

As of today, tick bites are becoming a significant problem in Ukraine not only among foresters [25,29], but also in children and adolescents, which can get the tick-borne diseases through recreational visits to the woody areas [19]. Additionally, awareness about tick bites among youth in Ukraine remains fairly low [16].

Humans can decrease their chances of tick bites by wearing light-colored clothing (including pants and long sleeves), which completely cover skin, by use of insect repellent with N,N-Diethyl-3-methylbenzamide (DEET), picaridin, or ethyl-3(N-n-butyl-N-acetyl)-amino propionate, by frequent checking for ticks while inside woody areas and after leaving them [11].

Generally speaking, ticks must be removed as early as it is safely possible, once they are discovered [21,22]. Meth-

ods for tick removal were intensively reviewed [6,8,23], which can be implemented either by patients themselves or by medical professionals (general surgeons) or health-care practitioners at the local trauma centers [18,21].

The *purpose* of the current research was to analyze questionnaires performed among forestry workers of seven regions of Ukraine on correlation of seeking / non-seeking professional medical help for tick removal with further medical complications and awareness of tick-borne diseases and to review literature on professional / surgical tick removal procedures, general recommendations on tick removal.

Materials and methods of the research

The questionnaire was conducted among total of 1070 forestry workers (972 males and 98 females) of seven regions of Ukraine. Respondents, which answered 'I don't remember' to the question about history and number of tick bites, were excluded from the study.

The responses to the questionnaire analyzed in this study were age, sex, region location, history of tick bites (1–2 or many), migratory erythema (ME) formation after the bite, method of tick removal, repellent usage, self-inspection after forest visits, and awareness.

Additionally, it was estimated that circa 40% of the analyzed population, which claimed tick bites, had children aged 0 to 18 years old in their domiciles.

All the respondents were tested for LB by one-stage serological screening procedure by the enzyme-linked immunosorbent assay (ELISA) method for specific IgM and IgG antibodies against *B. burgdorferi* (Euroimmun AG company, Germany). According to the manufacturer's manual, a value of ≤ 16 Units/ml was recorded as a negative result, 16 to 22 Units/ml – an intermediate, and ≥ 22 Units/ml – a positive. As the specificity and the sensitivity for the ELISA (IgM) test kit are equal to 96.4 and 100%, respectively, and for ELISA (IgG) test kit – 90.2 and 100%, respectively, we considered only any positive (IgM or IgG) result as a presumptive positive LB result.

Five 2 by 2 contingency tables were built with the same two groups (either seekers for professional tick removal or not seekers) and two levels: males and females; 1–2 and >3 tick bites; repellent usage (seldom / often) or no usage; skin self-inspection (seldom / often) or no self-inspection; awareness (low: insufficient + minimal vs. high: average + sufficient) to analyze factors which may lead to the seeking of professional tick removal.

Two 2 by 2 contingency tables were built with two outcomes (ME presence or absence; presumptive LB positive result and LB negative result) to analyze consequences of visiting or not visiting doctor for professional tick removal.

A Pearson chi-squared (χ^2) test at $p < 0.05$ was done as

Table 1

Analyzed group of respondents (total, males, females), claiming tick bites and excluding those who do not recall any tick bites at all

Region	Category	Respondents	Average age \pm standard deviation
Chernihiv	Total	92	46.4 \pm 11.0
	Males	85	46.3 \pm 10.8
	Females	7	47.4 \pm 13.4
Chernivtsi	Total	24	36.4 \pm 11.4
	Males	23	37.0 \pm 11.2
	Females	1	21.0 \pm N/A
Khmelnyskyi	Total	109	43.1 \pm 10.8
	Males	96	43.0 \pm 10.8
	Females	13	44.4 \pm 10.9
Ternopil	Total	240	42.9 \pm 11.0
	Males	235	42.7 \pm 11.0
	Females	5	51.0 \pm 7.1
Volyn	Total	89	40.3 \pm 11.5
	Males	73	40.0 \pm 12.0
	Females	16	42.0 \pm 11.0
Zakarpattia	Total	44	36.8 \pm 10.5
	Males	41	37.0 \pm 10.1
	Females	3	34.7 \pm 18.8
Zhytomyr	Total	72	41.1 \pm 10.6
	Males	58	39.5 \pm 10.5
	Females	14	47.0 \pm 9.0
Overall	Total	670	42.3 \pm 11.2
	Males	611	42.0 \pm 11.2
	Females	59	44.7 \pm 11.2

Note: N/A – not applicable.

a test for association to analyze if observed frequency distributions differ from expected distributions. Odds ratios (OR) and the confidence intervals (CI) were calculated ($\alpha=95\%$) for the same contingency tables to measure this association and its significance.

Spearman rank order correlation ($p < 0.05$) between age and seekers / non seekers of medical help for tick removal was calculated as well. Each non-seeker was assigned a value of 0, while each seeker – a value of 1.

The study was performed in accordance with the principles of the Helsinki Declaration. The study protocol was approved by the local ethics committee for all participants.

Results and discussion of the research

The analyzed group of respondents (total, males, females), claiming tick bites and excluding those who did not recall any tick bites at all, is shown in Table 1.

Overall, 670 respondents were included in the study, with males outnumbering females, probably due to the

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Table 2

Percentages of respondents who experienced tick bites and attended healthcare professional for tick removal

Region	Ternopil	Chernivtsi	Zhytomyr	Chernihiv	Zakarpattya	Volyn	Khmelnyskiy	Overall
Males	8.5	4.3	5.2	9.4	7.3	4.1	5.2	7.0
Females	20	100	7.1	28.6	0	6.3	0	10.2
Total	8.8	8.3	5.6	10.9	6.8	4.5	4.6	7.3

specificity of the forestry field, by more than 10:1 (Table 1). The average age ± standard deviation for all males was 42.0±11.2 y.o. (range 19 to 68 y.o.), matching one for the females with 44.7±11.2 y.o. (range 18 to 65 y.o.). The region with the ‘youngest’ forestry workers included in the analyzed population was Chernivtsi – 36.4±11.4 y.o., while the ‘oldest’ region was Chernihiv (46.4±11.0 y.o.).

Additionally, circa 40% of the surveyed forestry workers had children aged 0 to 18 years old, which lived in their domicile, and over which they had direct influence speaking of habits, behavior models, values, and dissemination of knowledge.

The percentages of those, who attended a doctor to remove attached tick, across different regions, are shown in Table 2.

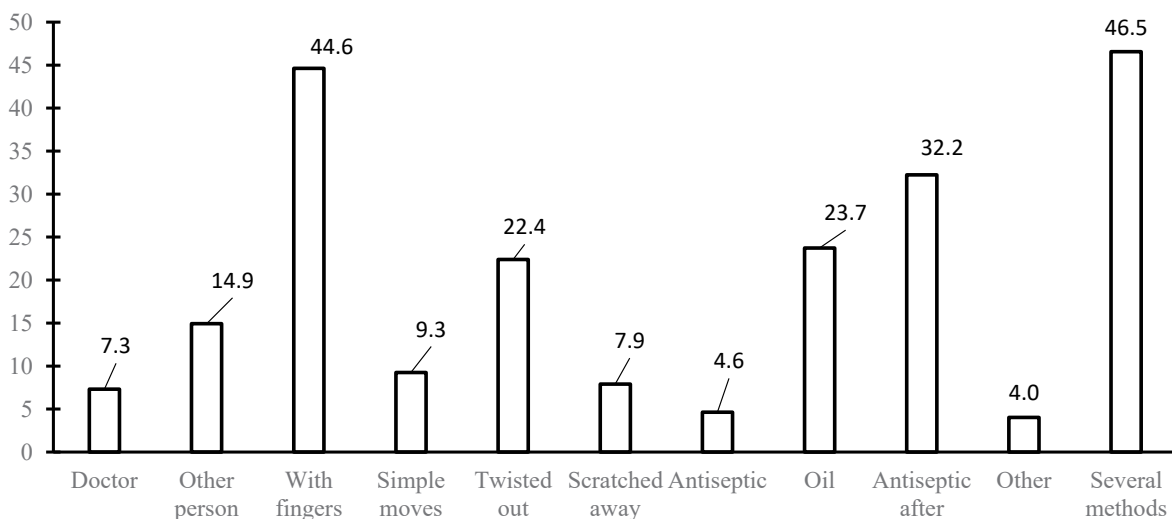
Overall, 7.3% of the respondents sought professional medical help for tick removal, with 7.0% males and 10.2% females. The region with highest percentage of forestry workers attending professional help was Chernihiv (10.9%), followed by Ternopil (8.8%) and Chernivtsi (8.3%). Volyn and Khmelnytskyi respondents sought medical attention less often – 4.5% and 4.6%, respectively.

A group of leading Ukrainian researchers in their monograph recommended immediate seek of professional help at either the local trauma center or hospital, upon observance of the tick bite. If professional help is

not available, they recommended removal of the tick by patients themselves with fingers wrapped up with gauze napkin or with blunt tweezers by simple pulling, but insisted for full removal of the tick with mouthparts included [2]. Additionally, sterile fine-tipped tweezers or similar professional tools, such as tick-twister, inserted between the body of the tick and the skin can be used; burning of the tick or use of toxic chemicals (oils, petroleum products) are highly not recommended [4]. If hypostome or any part of the tick remains inside the skin, they should be removed with sterilized needle. The bite area must be treated with any antiseptic, such as 3% iodine solution or alcohol [2].

The Center of Public Health of Ukraine of the Ministry of Health of Ukraine in their online publication suggested that infection with pathogens is unlikely if tick has been attached for less than 24 hours, but highly likely, if attachment lasted for more than 72 hours [13]. The catch-22 of seeking medical attention for tick removal is a need for time, while it is recommended to remove tick as soon as possible [13]. Also, finding a sterile instrument outdoors seems problematic, the better solution might be seeking professional help, especially within 24 hours after tick bite.

Analysis of all methods of tick removal techniques included in the questionnaire by the forestry workers are shown in Figure 1.



Note: total is more than 100% as each forestry worker could choose more than one method.

Fig. 1. Percentages of different methods of tick removal included in a questionnaire chosen by forestry workers of investigated population

Almost half (44.6%) of the forestry workers claimed to remove ticks with bare fingers, with 7.9% by scratching away, 9.3% by simple moves, and 22.4% by twisting it out. Regarding twisting, it was recommended by the CDC (Centers for Diseases Control and Prevention, USA) not to twist the tick out, unless a special grooved tool is available, as twisting may break off mouthparts inside the skin [5]. Finalizing the process with disinfectant application to the bite area, such as rubbing alcohol, as well as washing hands with soap, is a must [5]. When removing ticks, squashing of the body is prohibited, which can disseminate *Borrelia* from the intestines of the tick on the wound. Similarly, leaving injected cement behind in the skin, as well as parts of hypostome, can lead to secondary bacterial infection, allergic irritation from tick proteins, or forming granulomas [21]. Therefore, significant percentage of the Ukrainian forestry workers may perform procedures for tick removal by an inappropriate way, increasing risk of *Borrelia* dissemination on the skin, secondary bacterial infections, and formation of granulomas. Such behavioural habits can be shared and passed to the children in the domiciles, which may increase their risk of getting infection after tick bites as well. As for the antiseptic use, only 4.6% of the forestry workers used antiseptic as a tool to remove ticks, while 32.2% used it after tick removal to disinfect skin and avoid infections. Such low usage of antiseptics among forestry workers must be addressed as well. Oil to suffocate attached hard tick was used by 23.7% of all forestry workers, though D.W. Pitches wrote that using of chemical irritants, such as oil or petroleum jelly, which persuade tick to detach due to tick irritation or suffocation, may have opposite effect of causing tick to inject salivary fluid into the host and regurgitate, increasing transmission rate [20]. Waiting of the tick to suffocate does not seem to be practical as insect's respiration rate is low 3 to 15 breaths per hour) and with increasing attachment time, risk for *Borrelia* transmission increases [7]. Similarly, G. Needham noted that petroleum jelly, 70% isopropyl alcohol, and burning with kitchen match failed to detach tick [15].

Interestingly, one Spanish study showed that using sterile forceps for tick removal, comparing with other methods, significantly less likely caused complications, such as erythema migrans or secondary bacterial infections [17].

Three commercially available special tools for tick removal, while comparing with conventional forceps, did not provide any advantage. Forceps with tools designed to grasp were more successful to remove adults, while V-shaped groove was more successful for removal of immature nymphs without leaving any parts behind [27]. G.G. Duscher et al. reviewed five commercially available devices for hard tick removal, which included different

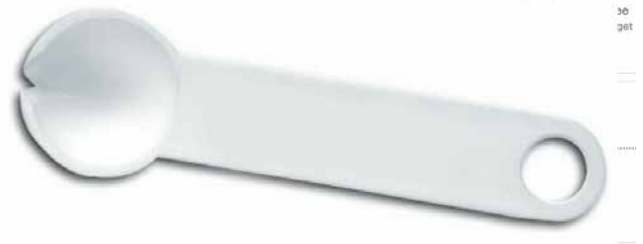


Fig. 2. Example of bowl-shaped, V-shape groove instrument for tick removal



Fig. 3. Example of tick twisting device for tick removal

Fig. 4. Example of forceps for «grab and pull» tick removal

mechanisms of seizing and holding, as well as ways of extraction (pulling, twisting, or scooping / grabbing) [7]. They noted that grabbing the mouthparts with V-shaped slot device and twisting devices provided the best results [7]. Examples of different commercially available tick removal tools are shown (Figures 2, 3, 4).

A group of Turkish researchers noted that the majority of ticks attached to the patients admitted to the investigated emergency department were removed by healthcare professionals (77.4%), while 22.6% of patients removed them themselves by hands [24]. Ticks crushed and broken off due to the technical mistakes during removal were more commonly seen in patients attempting self-removal without professional help [23].

Pearson chi-squared value and p-value significance of two levels of different factors influence on seekers and non-seekers of professional tick removal, as well as odds ratios and confidence intervals, are shown in Table 3.

As for chi-squared test for association (Table 3), only awareness had significant influence on the decision of either seek professional medical for tick removal or not ($p < 0.05$).

The interpretations of the odds ratios are as follows:

1. The odds of seeking professional tick removal among males is 0.67 times of the odds among females.

2. The odds of seeking professional tick removal among those with 1–2 bites is 1.45 times of the odds among those with >3 bites.

3. The odds of seeking professional tick removal among those who use repellants is 1.64 times of the odds among those who do not use them.

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Table 3

Pearson chi-squared test and odds ratios with confidence intervals for analyzed levels of influence on professional tick removal decision

Levels of influence on seekers vs non-seekers of professional tick removal	Chi-squared test (1, N=670), p-value	Odds ratio, Confidence intervals (α=95%)
Males vs females	0.7785 0.3776	0.67 0.2721–1.6437
1-2 vs >3 tick bites	1.5564 0.2122	1.45 0.8079–2.5893
Repellent usage vs no usage	2.2365 0.1348	1.64 0.8535–3.1360
Skin self-inspection vs no self-inspection	0.6415 0.4232	1.47 0.5683–3.8137
Awareness about Lyme borreliosis, low vs high	12.3091* 0.0005	2.78** 1.5392–5.0128

Notes: * - chi-squared-test significance at p<0.05; ** - odds ratio is significant.

Table 4

Pearson chi-squared test and odds ratios with confidence intervals for analyzed levels of influence on migratory erythema and Lyme borreliosis positive diagnosis

Seekers vs non-seekers of professional tick removal influence	Chi-squared test (1, N=670), p-value	Odds ratio, Confidence intervals (α=95%)
ME presence vs. absence	2.9899 0.0838	1.70 0.9261–3.1260
LB positive vs. LB negative	5.0167* 0.0251	0.47** 0.2413–0.9224

Notes: * – chi-squared-test significance at p<0.05; ** – odds ratio is significant.

4. The odds of seeking professional tick removal among those who perform self-inspection after visiting woods is 1.47 of the odds among those who do not check for the ticks after visiting woods.

5. The odds of seeking professional tick removal among those who consider themselves well informed about LB is 2.78 of the odds among those who consider themselves poorly informed about LB.

However, only awareness lower limit and upper limit of the confidence interval did not cross the value of 1.0 at α=95%, making it statistically significant (Table 3). Nevertheless, we can still speculate, that males should be more targeted for educational purposes to increase seeking professional medical help for tick removal, while encouragement for repellent use and self-inspection after visiting woods may co-stimulate seeking of professional medical help after the tick bite.

Results of analysis of seeking or non-seeking of professional tick removal influence on ME formation and LB serological result are shown in Table 4.

Interestingly, only LB positive or negative result was significantly influenced by whether forestry worker went to seek professional help for tick removal (p<0.05) using χ² test, while ME formation χ² test statistics was at the borderline (p-value=0.0838).

The interpretations of the odds ratios are as follows:

1. The odds of ME development among foresters who sought medical attention was 1.70 times of the odds among foresters, which did not seek.

2. The odds of LB positive results among foresters who sought medical attention was 0.47 times of the odds among foresters, which did not seek.

We can speculate that in some cases ME in those not seeking medical help for tick removal may have been unattended and unseen, while those who sought medical help for tick removal may have exaggerated and misinterpreted their skin condition.

Spearman rank order correlation value of -0.0257 between age and seeker / non-seekers of professional tick removal was non-significant at p>0.05, and suggested no association between age and decision to attend doctor in order to professionally remove hard tick.

O.V. Ozkan suggested to surgically excise the tick together with the part of the bitten skin in order to avoid disturbing tick and causing him to regurgitate, as well as to be sure to remove hypostome and cement from the skin [18]. Such procedure, compared to self-removal by the patient, eliminates the risk of incomplete removal or crushing in case of tiny size of the tick, such as nymph [18,22]. S. Roupaikas et al. employed a procedure described in Murtagh's «General Practice» for surgical tick

removal, consisting of five steps, which excluded even touching the tick [21]:

1. Subcutaneous xylocaine injection.
2. Limited skin excision (epidermis and dermis, diameter and depth equals to 2 to 3 mm) of the entire surrounding bite area.
3. En-block complete tick removal with skin portion.
4. Wound closure with a single stitch of 6–0 nonabsorbable suture.
5. The dermal wound stitch is removed on the sixth postoperative day.

The advantage of this procedure was the absence of tick touching, as even touching the tick or its death in situ, according to the author, may cause tick to irritate and force more liquid with *Borelia* into the wound. Very small ticks, such as nymphs, can be removed without squashing them and avoiding dissemination of the borrelia. None of the patients with such procedure applied had any systemic or local wound complications [21]. The authors recommended this surgical method not only for smashed ticks, small nymphs, over-24-hours attached ticks, but for all tick bites, mentioning only disadvantage as minimal invasiveness. The method was applied to patients 6 to 65 years old and was well tolerated by cooperative children [21]. K. Miyamoto and Y. Hashimoto suggested surgical removal of the tick if attachment lasted longer than 24 hours, as the tick fills with ingested host blood and any disturbance of the insect can cause it to regurgitate into the host [14].

Conclusions

Only 7.3% of forestry workers overall, with 7.0% males and 10.2% females, visited medical establishments to professionally remove attached ticks. Such irresponsible behavior may be passed to the children in their domicile and future generations. Forestry workers, who consider themselves well informed about LB, were more likely to seek professional help for tick removal; such tendency was also observed for female workers, for those bitten less times in their professional carrier, for those who use insect repellents and perform self-inspection after visiting woody areas. No correlation between age and decision to professionally remove tick was found ($r=-0.0257$, $p>0.05$).

Almost half (44.6%) of the forestry workers claimed to remove ticks with bare fingers, with 7.9% – by scratching away and 22.4% – by twisting out; 23.7% of all forestry workers used oil to suffocate ticks, all of which is not recommended. Only 32.2% of forestry workers used disinfectants after tick removal.

The odds of LB positive results among foresters who seek medical attention for tick removal was 0.47 times of the odds among foresters, which did not seek, in this specific study.

The surgical procedure for tick removal is described in literature, may decrease chances of tick-borne diseases spread, and should be considered for further implementation at Ukrainian medical establishments.

To summarize, forestry workers, as well as other sensitive population, including children, should be better educated regarding benefits of seeking professional tick removal after the bite. Moreover, seeking immediate professional medical help may also improve treatment of further medical complications in case of borrelia infection, as the doctor at the trauma center may explain symptoms of LB and further sequence of actions for the patient.

Financing. This study was done within complex research projects of the Department of Infectious Diseases with Epidemiology, Skin and Venereal Diseases of Ivan Horbachevsky Ternopil National Medical University – «Study of the epidemiology, pathogenesis and clinic of Lyme borreliosis in endemic regions of Ukraine, including the Ternopil region, and improvement of its diagnosis, therapy, rehabilitation measures and prevention» (state registration number 0118U000357) and «Mono- and mixed infections transmitted by ticks, improvement of medical and diagnostic technologies and biosecurity measures» (state registration number 0120U104348), which are both partially financed by the Ministry of Health of Ukraine.

No conflict of interests was declared by the authors.

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Стаття надійшла до редакції 21.12.2022 р., прийнята до друку 14.03.2023 р.