COMPLEX ASSESSMENT OF THE RELEVANCE OF CRITERIA OF THE FORENSIC DETERMINATION OF THE RECENTNESS OF BRUISES AND BRUISES WITH ABRASION FORMATION FOR THE DEVELOPMENT OF EXPERT DIAGNOSTIC PROGRAMM

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Summary

The development of information technology allows to increase the objectivity and accuracy of forensic examinations of mechanical trauma. A comprehensive assessment was made with the help of modern computer programs of the significance of the criteria for forensic determination of the age of 2290 bruises and bruises with abrasions.

Key words: bruise, abrasion, Cox model, Ordinal logit model, expert diagnostic program.

Introduction

Forensic examination of individuals in the presence of mechanical trauma includes two stages: first, identification of the victim, clarification of case details, detailed description of lesions, and in the second turn – analysis of the obtained information, that should be most effective, and preferably in the mode of express diagnostics [1]. In general, these provide high quality of the expertise, including determination of the recentness of the development of the pathologic process. But development of the modern technologies provides for the increase of the objectiveness and preciseness of this expertises, including cases when different by the character mechanical injuries can be determined in one victim.

The aim of the study was a complex assessment of the significance of criteria of forensic assessment of the recentness of bruises and bruises with abrasions occurrence for the development of expert diagnostic program.

Materials and methods

Archive documents of the department of the forensic expertise of victims, accused and other individuals of Vinnytsia regional bureau of forensic expertise for the periods of 2013-2014 years were investigated. 4289 “Expert conclusions” for the assessment of the character and severity levels of bodily damage were studied, 536 had descriptions of 2290 bruises, 163 described abrasions on the background of bruises, and 150 had bruise and bruise with abrasion. Among 536 investigated 286 were men, 250 – women. Age was from 7 to 83. An information on the presence of the disease, that might affect the dynamics of the post-traumatic process development were missing in all “Experts conclusions”, data about the use of medicines that may promote healing was also missing. Trauma recentness (in hours) was determined by the case circumstances and time of the expertise.

The number of bruises in one victim ranged from 1 to 60, bruises with abrasions – from 1 to 4. All this injuries occurred due to the strike with blunt hard objects or due to the fall on this objects. The next characteristics were mentioned in the document for each injury: localization, form, size, color of the bruise, presence of the skin swelling in the damaged area and macroscopic characteristics of abrasions (in their presence). For the assessment of color and size of the injury the color scale is used by the department of the forensic expertise of victims, accused and other individuals of Vinnytsia regional bureau. [2]

At the first stage of the work all information was transformed into the digital one and included into two separate tables for bruises and bruises with abrasions (Table I, Table II) [3]. Second table differs with the column that includes characteristics of abrasions.

Numerical order of the document was mentioned first, if several injuries were described in one document, then the numerical order was repeated. Male sex was marked as 1, female – 2, age was mentioned in full years. Recentness of the trauma was assessed in hours.

According to the localization on the body all injuries were divided into 6 groups: 1- head and neck, 2- shoulder and forearm, 3- trunk, 4- hips and buttocks, 5- forearm and hand, 6- shin and foota. Area of the injury was calculated according to its form and size, using corresponding formula and taking into account that they had spherical, oval shape or shape of irregular oval. According to the color all bruises were divided into 6 groups: 1- red or violet, 2- presence of red and purple at the same time or blue-red color, 3- presence of red or yellow-green at the same time, or green color, 4- purple (red-violet, blue-red), 5- presence of purple (red-violet, blue-red) and yellow-green at the same time, 6- yellow-green or yellow. Absence or presence of the swelling in the traumatized area was also mentioned (0 – absent, 1 – present).

Abrasions with macroscopic characteristics were divided into 6 groups; 1-fresh abrasion (wet dark-red surface), 2-presence of the crust on the abrasion, that is located lower than the skin level, 3- presence of the crust on the abrasion, that is located at the skin level 4- presence of the crust on the abrasion, that is elevated over the skin level, 5-crust slides off, 0-trace of the abrasion (depigmented surface).

Numerical order	№ of the document	Age	Sex	Recent-ness	Localiza-tion	Surface	Color type	Swelling
1	1	49	2	76	5	0,79	6	0
2	1	49	2	76	5	2,04	6	0
3	1	49	2	76	5	2,36	6	0
4	1	49	2	76	5	5,65	6	0
5	1	49	2	76	3	5,65	6	0
6	2	26	1	110	1	21,6	6	0
7	2	26	1	110	3	1,65	6	0
8	2	26	1	110	2	2,36	6	0
9	2	26	1	110	3	3,93	6	0
10	2	26	1	110	3	7,07	6	0
2290	523	20	2	147	2	4,0	6	0

Table I. Diagnostic criteria of the time of bruises occurrence

Numerical order	№ of the document	Age	Sex	Recentness	Localization	Surface	Color type	Swelling	Macroscopic characteristics of abrasion
1	1	49	2	76	5	0,79	6	0	3
2	1	49	2	76	5	2,04	6	0	3
3	1	49	2	76	5	2,36	6	0	3
4	1	49	2	76	5	5,65	6	0	3
5	2	26	1	110	3	5,65	6	0	3
6	2	26	1	110	1	21,6	6	0	3
7	2	26	1	110	3	1,65	6	0	3
8	2	26	1	110	2	2,36	6	0	3
9	2	26	1	110	3	3,93	6	0	3
10	2	26	1	110	3	7,07	6	0	3
441	163	20	2	336	4	6,28	6	0	0

Table II. Diagnostic criteria of the time of bruises with abrasions occurrence

At the second stage complex assessment of the influence of age and sex of victims, visual characteristics of bruises and abrasions on the dynamic of post-traumatic process was performed using Cox-model and Ordinal logit model using statistical analytical ***system R, survival library, coxph procedure*** [4, 5]. Next characteristics were determined: β-coefficient of regression, m-mistake of regression coefficient β, Z-statistics, index that is equal regression coefficient β divided by the mistake of the regression „ β, P-confidence level, k1-k5-threshold coefficient. It is important to mention, that negative value of the regression coefficient β indicates a delay of the accident, so a decrease of the probability of its occurrence, while positive value indicates an acceleration of the accident occurrence, so an increase of the probability of its occurrence. Exp(β) indicates relative risk of the accident occurrence.

Results

Results of the mathematic analysis of the influence of age and sex of victims, visual characteristics of visual characteristics of bruises on the dynamics of post-traumatic process according to the Cox-model are presented in the Table III.

Characteristics	β	Exp(β)	M	z	p
Age	-0.001	0.999	0.02	0.51	0.61032
Sex	0.002	1.002	0.045	0.05	0.96378
Localization 2	0.177	1.193	0.061	2.88	0.00401
Localization 3	0.024	1.024	0.073	0.32	0.74754
Localization 4	-0.008	0.992	0.080	0.10	0.91819
Localization 5	0.187	1.206	0.069	2.73	0.00629
Localization 6	0.151	1.163	0.090	1.68	0.09238
Area	-0.004	0.996	0.001	4.79	1.72E-06
Color type 2	0.414	1.513	0.113	3.66	0.00026
Color type 3	-1.868	0.154	0.163	11.47	2.00E-16
Color type 4	-0.277	0.758	0.102	2.71	0.00674
Color type 5	-1.725	0.178	0.106	16.22	2.00E-16
Color type 6	-2.623	0.073	0.129	20.31	2.00E-16
Swelling	0.210	1.234	0.064	3.28	0.00104

Table III. Results of the mathematic analysis using Cox model of the recentness of bruises occurrence

Taking into account, that the number of investigated subjects was significantly smaller than the number of investigated bruises, and that the number of lesions varies from 1 to 60 in one person, we decided to study an impact of age and sex on the dynamics of the color change of the bruise using Ordinal logit model. Obtained data is represented in the Table IV.

Factors	B	exp(β)	M	z	p
Age	0,011758	1,0117	0,002504	4,695	2,66E-06
Sex	0,040845	1,0414	0,076899	0,531	0,595
	Threshold coefficient	Value	M	Z	
	k1	-2,4675	0,1731	-14,255	
	k2	-1,1125	0,1546	-7,195	
	k3	-0,9348	0,1536	-6,086	
	k4	0,7476	0,1534	4,873	
	k5	2,9925	0,1698	17,624	

Table IV. Calculation of the age and sex impact on the dynamic of the color change of the bruise using Ordinal logit model

At the next stage of statistical analysis we used Cox model for the assessment of the impact of the diagnostic features on the recentness of the bruises with abrasions occurrence. Obtained data is represented in the Table V.

Characteristics	β	Exp (β)	m	z	p
Age	-0,001	0,999	0,005	0,20	0,84488
Sex	-0,215	0,807	0,104	2,07	0,03881
Localization 2	0,820	2,271	0,351	2,34	0,01934
Localization 3	0,043	1,044	0,323	0,13	0,8945
Localization 4	0,114	1,120	0,435	0,26	0,79383
Localization 5	-0,336	0,715	0,326	1,03	0,30274
Localization 6	-0,237	0,789	0,497	0,54	0,58811
Bruise area	0,003	1,003	0,005	0,68	0,49389
Color	-0,326	0,722	0,061	5,33	9,70E-08
Swelling	-0,754	0,470	0,396	1,90	0,05719
Macroscopic characteristic of the abrasion	-0,414	0,661	0,112	3,68	0,00023

Table V. Results of the mathematic analysis of the diagnostic criteria of the recentness of the bruises with abrasions using Cox model

Discussion

According to the results represented in the Table III, sex and age of the investigated subjects do not influence the recentness of the trauma. Bruises located on the upper limbs are healed significantly (from 1,193% to 1,206%) than those of different localization. Bruises located on the hips a healed slower (on 0,992%)/ but this is not a significant difference (p=0,91819).

Healing time of the bruise (1,70E-06) depends reliably on its area: with an increase of the healing time slows down. With an increase of the bruise area on 1 % above average (13,83 cm^2) healing time is increased by 0,996%.

Recentness of the bruise correlate with its color (p= from 0,00674 to 2,00E-16), which allows to define this diagnostic criteria as the most informative. And the bigger is the term of the bruise existence the slower colors change each other, starting from the third color type, which characterize the period of bruise “bloom”.

Presence of skin swelling in the area of lesion localization reliably (p=0,00104) depends on its recentness and characterizes initial stages of its development.

Data represented in the Table IV indicates, that the age of the victims reliably (p= 2,66E-0) influences the dynamics of the color change of the bruise in the posttraumatic period. Threshold coefficient k5 is 2,9925, that indicates that age influence the last stage of the bruise development the most, when it has yellow or yellow-green color. The tendency can be noted, that women have faster healing of the injuries than men (β = 0,040845) but this tendency is not significant in such number of observations.

According to the result represented in the Table V, age of the investigated subjects does not influence the recentness of the trauma, while sex does (p=0,03881). Healing in women is slower than in men. When the influence of the trauma localization on the healing process was studied, it was found that the bruises with abrasions, that are located on the upper limbs a healed reliably faster (on 2,271%), than those located on the head, neck, trunk, hips, buttocks, shins and feet. Those located on hips disappear slower (on 0,789%), but this dynamics is not reliable (p=0,58811).

There is no significant relation between the healing time of bruise with abrasion and its area, but there is a tendency that with the area increase the time of the bruise with abrasion healing is increased (on 0,003%).

Recentness of the occurrence of bruise with abrasion correlate with its color (p=9,70E-08), that allows to define this diagnostic criterion as most informative.

Presence of the skin swelling in the area of localization of the bruise with abrasion reliably (p=0,05719) depends on its recentness and characterize initial stages of its development.

Mathematical analysis have shown, that macroscopic characteristics of the abrasion reliably depends on the recentness of the trauma (p=0,00023). Each following stage of the development of this lesion is longer than the previous (β = -0,414).

Conclusions

1. Healing speed of the bruise and bruise with abrasion depends on the age of the victim: the older is the victim the slower is the process, and this dependency occur at the last stage of its development (yellow color). Impact of sex on this process requires additional investigation.
2. The most informative criterion for the diagnosis of the bruise recentness is its color. Change of the color is faster at the upper limbs, slower at hips and with the increase of the lesion area. Swelling of the soft tissues accompanies initial stages of the traumatic process, when skin has purple, blue-red color.
3. Macroscopic characteristics of the abrasion, located on the background of the bruise, are additional reliable criterion (if present) for the assessment of the bruise recentness. Abrasion presence does not impact the character of the color change of the traumatized skin.
4. Complex assessment using Cox-model and Ordinal logit model of the criteria of the diagnosis of the bruise recentness allows to create an algorithm of this diagnostics. It is based on the principles of the skin color change of the traumatized skin in the dynamics of posttraumatic period with inclusion of the impact of other criteria. This can be a basis of the expert diagnostic program [6, 7], with the use of modern objective methods of the color and lesion area registration.

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