

Determination of the informativeness of the criteria for diagnosing timing of bruising by the Cox model

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Abstract

Establishing the age of damage is one of the most important issues that is solved during the forensic examination. The purpose of the work was to determine of the informativeness of the criteria for diagnosing timing of bruising by the Cox model. In research, which consists of 2291 bruises, described in 523 victims, 7 diagnostic features were described: gender, age, shape and size of bruising, its location, colour, and the presence of oedema of the skin. The informative nature of these features was determined by the Cox model and the Ordinal logit model. The victim's sex does not affect the development of bruising. Age slows down this development. Bruises that are located on the upper limbs heal faster than other localization, and located on the hips and buttocks - slower. The rate of healing of bruises reliably depends on its area: with an increase in area by 1%, the time of healing of bruising slows by 1%. The process of healing of bruises reliably depends on its colour: the longer the bruise exists, the slower the rate of change of one colour to another. The presence of swelling of the skin depends on its age and characterizes the initial stages of its development. Conclusions: of the 7 diagnostic signs to establish the age of bruises - 6 have an informative value, and most among them have their colour, on condition that it is divided into 6 parameters (colour groups). The dynamics of colour change affects the person's age. On the upper limbs, the bruising heals faster, on the hips and buttocks - slower. The healing rate on the straight line depends on its area, with the increase of the area - the healing rate slows down. The presence of swelling of the skin is characteristic in the early stages of bruising, which increases the reliability of the diagnosis in these terms.

Key words: forensic medical diagnostics, bruise, the colour of bruise, Cox model

Stanovenie informatívosti kritérií pre diagnostikovanie časovania podliatin modelom Cox

Abstrakt

Stanovenie veku poranenia je jedným z najdôležitejších problémov, ktorý sa rieši počas súdneho vyšetrovania. Cieľom práce bolo zistiť informatívnosť kritérií na diagnostikovanie veku podliatin modelom Cox. V štúdií bolo skúmaných 2291 podliatin u 523 obetí, bolo sledovaných 7 parametrov: pohlavie, vek, tvar a veľkosť podliatin, ich umiestnenie, farba a prítomnosť opuchu kože. Informatívny charakter týchto vlastností bol určený modelom Cox a modelom Ordinal logit. Pohlavie obete neovplyvňuje vývoj podliatin. Vek spomaľuje tento vývoj. Podliatiny, ktoré sa nachádzajú na horných končatinách, sa hoja rýchlejšie ako iné lokalizácie, pomalšie sa hoja na bokoch a v sedacej oblasti. Rýchlosť hojenia podliatin spoľahlivo závisí od rozsahu: s nárastom plochy o 1% sa čas hojenia podliatin spomaľuje o 1%. Proces hojenia podliatin spoľahlivo závisí od jej farby: čím staršia je podliatina, tým pomalšia je rýchlosť zmeny jednej farby na inú. Prítomnosť opuchu kože závisí od jej veku a charakterizuje počiatkové štádiá jej vývoja. Závěry: zo 7 diagnostických znakov na stanovenie veku podliatin - 6 má informatívnu hodnotu a väčšina z nich má svoju farbu, pod podmienkou, že je rozdelená do 6 parametrov (skupiny farieb). Dynamiku zmeny farby ovplyvňuje vek osoby. Na horných končatinách sa podliatiny hoja rýchlejšie, na bokoch a v sedacej oblasti pomalšie. Rýchlosť hojenia lineárne závisí od jej rozsahu, s nárastom plochy sa rýchlosť hojenia spomaľuje. Prítomnosť opuchu kože je charakteristická v skorých štádiách podliatin, čo zvyšuje spoľahlivosť diagnózy v týchto podmienkach.

Kľúčové slová: súdnolekárska diagnostika, podliatina, farba podliatiny, Cox model

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Introduction

Establishing the age of damage is one of the most important issues that is being solved during the forensic examination of both living persons and corpses. The difficulty of the solution lies on the one hand in the variety of mechanical factors and conditions of action on the human body, and on the other - in the complexity of the reaction of the organism to this effect. The development of modern information technologies makes it possible to expand the search limits of the most informative and rational methods of solving this issue, in particular, in the diagnosis of the timing of bruising [1].

The aim of the work was to determine the informative criteria of the Cox model in the course of forensic medical examination of living persons for the development of a diagnostic algorithm for the diagnosing timing of bruising.

Methods

In research, which consists of 2291 bruises described in 523 victims we studied 7 diagnostic features, which are described in 17 parameters. These attributes include: gender, age, shape and size of bruise, localization, colour, and the presence of oedema in the skin. The shape and size of the damage were determined by its area, which was calculated according to the standard formulas for determining the square of the oval. A colour scale specially developed for forensic medical research was used to determine the colour of bruises [2]. The presence or absence of swelling of the skin in the injury zone was indicated. The translation of verbal information characterizing the localization and colour of bruises was digitally conducted using the appropriate method [3]. By localization, bruises were divided into 6 groups: 1 - head and neck, 2 - shoulder and arm, 3 - torso, 4 - thigh and buttocks, 5 - forearm and hand, 6 - leg and foot. By colour, bruises were divided into 6 groups: 1 - red, or purple, 2 - red and purple, or blue-red, 3 - red and yellow-green, or yellow, 4 - purple (red-purple, blue-red), 5 - purple (red-violet, blue-red) and yellow-green, or yellow, 6 - yellow-green, or yellow. The mathematical analysis was conducted using the Cox model and the Ordinal logit model [4, 5] using the computer program "Statistics, system R, library survival, procedure coxph". The following characteristics were determined: β is the regression coefficient, m is the error of the regression coefficient, Z - statistic, the index equal to the regression coefficient β divided by the error of the regression coefficient β , P is the reliability level, k_1 - k_5 is the threshold coefficients.

The sign of the coefficients of regression β indicates the direction of the effect of the corresponding factor. Negative value indicates the "delay" of the event, that is, reducing the risk of its occurrence, while the positive about the effect of accelerating the event,

respectively, increasing the risk of its occurrence. $\exp(\beta)$ shows the relative risk of occurrence of the event.

Results

At the first stage of the work, all verbal information was translated into digital. The results were summarized in one table, which was adapted for further processing by the Cox model. Here is a sample of this table (Tab. 1).

In the first column of the table the serial number of the bruise was indicated, in the second - the serial number of the forensic document, if one document described several bruises, then the serial number of the document was repeated, in the third - the age of the victim (the number of full years), in the fourth - the sex - man (1), or woman (2), in the fifth - the time of occurrence of damage in hours, in the sixth - the localization (6 types), in the seventh - the area (cm²), in the eighth - the type of colour (6 variants), in the ninth - the presence of swelling of the skin (1), its absence (0). At the end of the table, the average values for age (number of full years), timing of bruises (in hours) and its area are indicated.

Serial number of bruises	Document No	Age	Sex	Timing of damage	Localization	Area	Colour type	Edema
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
Average value		38	-	58	-	13,83	-	-

Tab. 1 Joint table of diagnostic criteria for the occurrence of bruising

At the second stage of the work: with the help of the Ordinal logit of the model, the influence of the age and sex of the victims on the dynamics of colour change in the process of its development was studied. Such a wording of the question relates to the need to take into account the fact that one victim recorded one to sixty bruises. The results were summarized in the table (Table 2).

Factors	β	$\exp(\beta)$	m	z	p
Age	0,011758	1,0117	0,002504	4,695	2,66 E-06
Sex	0,040845	1,0414	0,076899	0,531	0,595
Threshold coefficients		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	

Tab. 2 Influence of age and sex of victims on changing the colour of bruises in the dynamics of the post-traumatic period

The data given in Table 2 indicate that the age of victims is significantly ($p = 2.66 \text{ E-}06$) affects the dynamics of colour changes in the post-traumatic period of bruising, and gender is not affected. The threshold coefficient k_5 is 2.9925, indicating that the age most influences the last stage of bruising when it has yellow, or yellow-green colouration.

At the next stage of statistical processing, we used the Cox model to assess the extent of exposure to all diagnostic features on the timing of bruises. The results obtained are presented in Table 2.

Characteristics	β	$\exp(\beta)$	m	z	p
Age	-0,001	0,999	0,002	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
Bruise area	-0,004	0,996	0,001	4,79	1,70E-06
Type of colour 2	0,414	1,513	0,113	3,66	0,00026
Type of colour 3	-1,868	0,154	0,163	11,47	2,00E-16
Type of colour 4	-0,277	0,758	0,102	2,71	0,00674
Type of colour 5	-1,725	0,178	0,106	16,22	2,00E-16
Type of colour 6	-2,623	0,073	0,129	20,31	2,00E-16
Swelling of the skin	0,210	1,234	0,064	3,28	0,00104

Tab. 3 Analysis of the influence of all investigated factors on the diagnosis of timing of bruising

The data given in Table 3 allowed establishing that the higher the victim's age, the more slowly healing damage, especially as shown by the preliminary analysis - in the last period of its existence, when it has a yellow or yellow-green colour. As the age grows by one percent above the average, (the average age in the study is 38 full years) the duration of the existence of bruises increases by 0.999%.

The bruises located on the upper extremities heal faster (from 1.193% to 1.206%) than on the head, neck, trunk, hips, buttocks, legs and foot. Located on the hips and buttocks disappear more slowly (by 0.992%), but this dynamic is not reliable ($p = 0.91819$).

The rate of healing of bruises reliably ($1.70\text{E-}06$) depends on its area: with an increase in area, the time of healing of bruising is slowing down. With an increase in the area of bruise by 1%, more than average (13.83 cm^2), the duration of healing increases by 0,996%.

The age of bruising correlates with its colour ($p = 0.00674 - 2.00\text{E-}16$), which allows to determine this diagnostic criterion as the most informative. Moreover, the longer the existence of the damage, the more slowly one colour changes to another, starts with the third type of colour, which characterizes the beginning of the "flowering" of bruising.

The presence of swelling of the skin in the zone of damage localization reliably ($p = 0.00104$) depends on its age and characterizes the initial stages of its development.

Conclusion

Thus, the statistical analysis of the Ordinal logit model and the Cox model of the seven diagnostic features established that an informative value for determining the timing of bruises have 6. The sex of a person as a diagnostic criterion is not informative. Among all the criteria, the most important is the colour, on condition that it is divided into 6 parameters (group of colours). The dynamics of colour changes affects the age of a person, the older the person, the healing rate is less. On the upper limbs, the bruising heals faster, on the hips and buttocks - slower. The healing rate correlates with its area, with the increase of the area - the healing rate slows down. The presence of swelling of the skin is characteristic in the early stages of bruising, which increases the reliability of the diagnosis in these terms.

References

1. Havryliuk AO. Perspektyvni napriamky sudovomedychnykh doslidzhen dlia vstanovlennia zashyttievosti ta davnosti sprychynennia tilesnykh uskodzhen v Ukraini (ohliad literatury). Bukovynskyi medychnyi visnyk. 2015;19(4 (76)).
2. Mokaniuk OI, Havryliuk AO, Perebetiuk AM, Dzharabaiev VS, Olchedai VM. Vstanovlennia koloru travmovanoi shkiry za dopomohoiu shkaly koloriv. Sudovo-medychna ekspertyza. 2011(4):15-16.
3. Mokaniuk OI. Suchasnyi pidkhid shchodo vyznachennia koloru syntsia pry sudovo-medychnii ekspertyzi zhyvykh osib (analiz arkhivnoho sudovomedychnoho materialu). Zbirnyk naukovykh prats spivrobitnykiv KMAPO im. P.L. Shupyka. 2001 (10):1310-1317.
4. Crawley MJ. The R book. John Wiley & Sons; 2012 Nov 7.
5. SAS Institute. SAS/ETS 9.1 User's Guide. SAS Institute; 2004.