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Estimation of postmortem interval based on the spectrophotometric analysis of postmortem lividity

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ABSTRACT

The color of postmortem lividity and control skin in 21 adult cadavers whose postmortem interval was within 72 h, was measured by spectrophotometry in order to estimate the postmortem interval, objectively. The $L^*a^*b^*$ system, which has been widely used for the digital expression of skin color, was used and linear regression analysis was performed to determine the relationship between the postmortem interval and 31 color factors including L^* (Value), a^* and b^* (Chroma and Hue) and C^* (Chroma). The difference in Chroma between postmortem lividity and control skin (ΔC^* and $\Delta C^*/C_c^*$) was only weakly correlated with the postmortem interval. We propose a new equation for calculating the postmortem interval using several color factors obtained by measurement of postmortem lividity, together with some autopsy findings that are known to affect the formation of postmortem lividity. The new equation makes it possible to estimate the postmortem interval within ±4.76 h.

1. Introduction

Postmortem lividity is a useful phenomenon for estimating the cause of death, such as carbon monoxide (CO) poisoning, cyanide intoxication and death from hypothermia. It is also used to estimate the postmortem interval [1]. However, assessment and description of the color of postmortem lividity is difficult because color recognition is subjective. To measure the color of postmortem lividity accurately, spectrophotometric analyses of postmortem lividity have been attempted, and objective, quantitative and reproducible color data have been reported [2–9]. However, to date there has been no equation for estimating the postmortem interval from the color of postmortem lividity plus autopsy findings. We formulated such an equation.

2. Materials and methods

2.1. Subjects

The color of postmortem lividity and control skin was measured in adult cadavers from forensic autopsy cases examined at Kyushu University between August 2007 and March 2008. The cause of death and postmortem intervals were determined after full autopsy examinations and complete police investigations. Cadavers whose postmortem interval was thought to be in excess of 72 h were excluded from this study because the intensity (lightness) of postmortem lividity becomes fixed by 72 h after death [5]. Charred bodies and cadavers that had undergone putrefaction were also excluded. One cadaver that had undergone attempted resuscitation for more than 8 h was also excluded. Thus, a total of 21 cadavers was included in this study, 17 males and 4 females. The following information on the subjects was recorded: age, sex, cause of death, circumstances surrounding the death, CO exposure, cold exposure, blood clots in the heart, massive hemorrhage, postmortem interval since dying declaration, and attempted resuscitation.

2.2. Measurement procedure

The skin site for evaluation was carefully inspected before measurement, and 1–8 points regarding postmortem lividity were selected from the front and the back of the upper and lower limbs, chest, abdomen, back, waist and hip. Skin without postmortem lividity was used as control. The color of each point was measured twice using a spectrophotometer, CM-2600d (Konikaminolta Co., Tokyo, Japan), and the average value was used to evaluate the color of postmortem lividity and the color of the control skin. The aperture of the spectrophotometer was set at 3 mm in diameter and the light source was D65. The instrument was calibrated just prior to each measurement and contact between the aperture and the skin was achieved with minimal pressure.

2.3. The $L^*a^*b^*$ color system

The $L^*a^*b^*$ system was introduced by the Commission Internationale de l'Eclairage (CIE) in 1976 and it has been widely used

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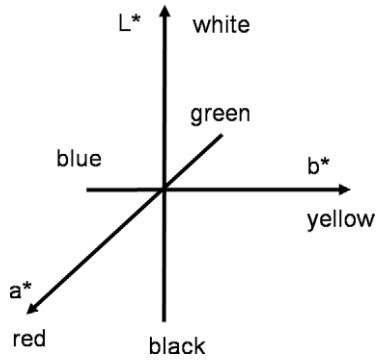

Fig. 1. $L^*a^*b^*$ system. L^*, brightness; a^*, red–green chromaticity coordinate; b^*, blue–yellow chromaticity coordinate.

for the digital expression of skin color [10]. In this system, L^* represents Value, while a^* and b^* represent Chroma and Hue. The L^* value specifies the position along the vertical light–dark axis (white = 100, black = 0), the a^* value specifies the position along the red–green axis ($+a$ = red, $-a$ = green), and the b^* value specifies the position along the yellow–blue axis ($+b$ = yellow, $-b$ = blue) (Fig. 1). In this paper, the difference in the color value between postmortem lividity and the control skin was expressed as Δ. Color differences between postmortem lividity and control skin (ΔE^*ab) and Chroma (C^*) were calculated as follows:

$$\Delta E^*ab = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

$$C^* = \sqrt{(a^*)^2 + (b^*)^2}$$

The metric Hue-difference (ΔH^*) was calculated as follows:

$$\Delta H^* = \sqrt{(\Delta E^*ab)^2 - (\Delta L^*)^2 - (\Delta C^*)^2} = \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2 - (\Delta C^*)^2}$$

The values of the following 31 factors were examined, control skin L^*_c, a^*_c, b^*_c and C^*_c, postmortem lividity L^*_l, a^*_l, b^*_l and C^*_l, ΔL^*, Δa^*, Δb^*, ΔH^*, ΔE^*ab, ΔC^*, a^*_c/L^*_c, b^*_c/L^*_c, $\Delta L^*/L^*_c$, b^*_c/a^*_c, $\Delta a^*/a^*_c$, $\Delta b^*/b^*_c$, a^*_l/L^*_l, b^*_l/L^*_l, $\Delta L^*/L^*_l$, b^*_l/a^*_l, $\Delta a^*/a^*_l$, $\Delta b^*/b^*_l$, $\Delta a^*/\Delta L^*$, $\Delta b^*/\Delta L^*$, $\Delta b^*/\Delta a^*$, $\Delta C^*/C^*_c$ and $\Delta C^*/C^*_l$.

2.4. The relationship between postmortem lividity and postmortem interval

The value of each factor was calculated using SpectraMagic® NX Basic (Konicaminolta Co., Tokyo, Japan). Linear regression analysis was performed to determine the relationship between the postmortem interval and the above 31 factors of the color specification system of postmortem lividity. A p-value of less than 0.05 was considered statistically significant.

2.5. The predictive equation for postmortem interval

Stepwise regression analysis was employed to establish the predictive equation for ascertaining the postmortem interval by

Table 1
Characteristics of subjects and color data obtained from postmortem lividity and control skin.

	Sex	Age	Cause of death	CO exposure	Cold exposure after death	Blood clots	Massive hemorrhage	Resuscitation	Informed postmortem interval (h)	Postmortem lividity			Control		
										L^*	a^*	b^*	L^*	a^*	b^*
1	F	59	Bilateral cervical artery cut off	–	–	+	+	–	24	63.17	6.38	7.03	76.37	−0.64	11.18
2	M	24	Arrhythmia due to hypertrophic cardiomyopathy	–	–	–	–	+	16	49.72	9.57	8.74	69.24	2.09	16.71
3	M	43	Acute amphetamine intoxication	–	–	–	–	–	30	58.09	9.43	13.31	67.69	2.86	15.93
4	M	37	Acute amphetamine intoxication	–	–	–	–	–	16	58.32	6.39	9.43	65.13	1.92	14.81
5	M	58	Aortic rupture	–	+	–	+	–	29	53.1	9.84	12.29	71.34	2.27	20
6	F	63	Ligature strangulation	–	+	–	–	–	60	53.07	14.14	15.13	72.17	2.05	16.41
7	M	55	Adhesion ileus	–	–	Chicken fat clot	–	–	27	54.62	10.88	15.88	60.41	5.77	18.44
8	M	52	Hypovolemia due to cardiac rupture from gun shot	–	–	–	+	–	22	54.4	7.04	14.2	66.76	2.87	18.6
9	M	49	Right ventricular frontal wall rupture	–	–	–	+	+	28	53.47	8.07	17.65	60.63	5.86	21.23
10	M	56	Hypovolemia due to rupture of left renal artery	–	–	–	+	+	6	61.79	6.7	16.03	69.54	2.85	19.33
11	M	37	Cardiac contusion	–	–	–	+	+	10	52.63	9.33	12.88	64.06	3.97	17.96
12	M	59	Pneumonia	–	–	–	–	–	20	50.67	13.93	13.1	68.39	1.38	19.02
13	M	38	Ischemic heart disease due to coronary artery atherosclerosis	–	–	–	–	+	21	56.76	6.53	7.19	68.7	2.86	16.16
14	M	52	Arrhythmia due to ischemic heart disease from coronary artery atherosclerosis	–	–	–	–	+	14	52.24	8.27	8.44	67.52	2.79	15.53
15	M	45	Choking due to inhalation of vomitus	–	+	Chicken fat clot	–	–	37	50.49	10.77	11.89	58.25	3.16	14.8
16	M	55	Hanging	–	+	–	–	–	42	56.17	6.62	12.16	68.98	3.45	18.91
17	M	54	Acute carbon monoxide intoxication	+	–	+	–	–	60	59.05	8.35	17.12	61.12	5.17	18.83
18	F	85	Pulmonary embolism	–	–	–	–	+	23	52.07	9.49	11.02	65.2	5.03	18.8
19	M	38	Hypovolemia due to rupture of left renal artery	–	–	+	–	+	25	58.8	8.41	10.99	70.8	2.89	16.33
20	F	94	Multiple organ failure	–	–	+	–	+	10	70.16	3.91	18.19	72.72	1.41	19.34
21	M	49	Drowning	–	–	+	–	–	33	54.57	9.81	14.22	66.06	2.96	16.78

M, male; F, female.