Post Mortem Cooling of the Body and Estimation of Time Since Death

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Summary

Estimation of time since death in the field of forensic medicine expertise is an issue of high interest, especially in case of violent death caused by unknown executor. Post mortem cooling of the body is one of the pertinent parameters in estimation of time since death during the early postmortem period.
Purpose of this paper is to analyze some of the existing methods, compare obtained results and determine which method gives more precise results of the estimation of time since death.
This paper presents the analysis of 50 cases autopsied at the Institute of Forensic Medicine and Criminology in Skopje, with known time of death. Rectal temperature was taken with digital thermometer. Simultaneously, environment temperature was measured as well as the body weight; it was recorded whether the body was covered or naked. In order to estimate time since death following methods were applied: Method I, Method II, Al-Alousi and Anderson and Henssge-nomogram.
Comparison of the known time of death with the time obtained by the applied methods has shown a discrepancy of few hours.
Comparison of results obtained by application of the above stated methods has shown that the Henssge-nomogram gives less discrepancy from the true time of death.

Key words: time of death – rectal temperature – ambient temperature – nomogram

Souhrn

Chladnutí těla post mortem a odhad doby úmrtí

Odhad doby úmrtí v oblasti soudně-lékařské expertízy je záležitostí těšící se velké pozornosti zejména v případě násilné smrti způsobené neznámým vrahem. Stydnutí těla post mortem je jedním ze souvisejících faktorů při stanovování času smrti během časného posmrtného období.
Cílem této práce je analyzovat některé z existujících metod, porovnat získané výsledky a určit, která z metod poskytuje přesnější údaje při odhadování doby úmrtí. Tato práce uvádí analýzu 50 případů pitev v Institutu soudního lékařství a kriminologie ve Skopje se známým časem smrti. Rektální tělesná teplota byla měřena digitálním teploměrem. Současně byla zjištěna teplota okolí, tělesná hmotnost, a bylo zaznamenáno, zda tělo bylo zakryto či bylo obnažené. Při odhadování doby uplynuvší od úmrtí byly použity následující metody: metoda I, metoda II a nomogramy dle Al-Alousiho, Andersona a Henssgeho. Porovnání známého času úmrtí a času odhadnutého použitými metodami ukázalo rozdíl několika hodin. Porovnání výsledků získaných použitím výše uvedených metod ukázalo, že nomogram dle Henssgeho udává menší rozdíly od skutečného času úmrtí.

Klíčová slova: čas úmrtí – rektální teplota – teplota okolí – nomogram

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Introduction

In the forensic medicine expertise the precise time of death is an issue of special interest in many cases after finding the body of the diseased. Preciseness of answers is substantial in the reconstruction and clarification of circumstances, particularly in murder cases, un-witnessed, killer unknown; in traffic accidents of car-hit casualties with driver escaped from the scene; and many other cases.

Estimation of time since death in the forensic medicine practice includes two expertises, one considering the early postmortem period and the other the late postmortem period when body has started to decompose. Preciseness of estimation of time since death decreases as time interval since death increases.

Approximately, time of death in the early postmortem period is routinely estimated by conventional methods of corpse examination by observing the development of postmortem changes.

Tab. 1. Cases with known time of death

Case	Age	Sex	Time since death (h)	T°C rectum	T°C ambient	Body weight (kg)	Body height (cm)	Cove-red	Causa mortis
1.	51	M	4	34,9	17	65	168	+	Infarctus myocardii
2.	54	F	4	34,4	22	65	160	+	Schock traumaticus
3.	54	M	4	35,1	19,3	78	180	+	Vulnera explosiva
4.	26	F	4	34,7	22,5	75	166	-	Electrocutio
5.	16	M	4	35,9	22,4	65	175	-	Contusio cerebri
6.	49	M	5	33	24	75	176	-	Intoxicatio cum pesticidi
7.	35	M	5	36,5	21	80	175	-	Vulnera sclopetaria
8.	38	M	6	32,8	22,4	80	174	-	Vulnera sclopetaria
9.	20	F	6	32,2	22	58	165	-	Schock traumaticus
10.	55	M	6	34	21	75	172	-	Embolia pulmonis
11.	58	M	6	33,2	16,5	60	158	+	Tamponada cordis
12.	69	M	6	33	20	78	173	-	Vulnera punctata
13.	52	M	6	34,1	24,5	70	166	+	Infarctus myocardii
14.	44	F	7	32	21	57	160	-	Intoxicatio cum HCl
15.	35	M	7	30,6	16	80	175	+	Schock traumaticus
16.	53	M	7	32,5	21,3	80	172	+	Insufitientio myocardii
17.	75	M	7	33	24	78	176	+	Schock traumaticus
18.	76	M	7	33,9	24	82	175	+	Schock traumaticus
19.	60	M	7	33,8	24	84	178	+	Schock traumaticus
20.	59	M	7	33	22,5	70	164	+	Schock traumaticus
21.	44	M	7	35,4	30	75	177	+	Electrocutio
22.	62	M	8	32	21	72	168	-	Embolia trombotica
23.	38	M	8	32,4	21,2	55	159	-	Infarctus cerebri
24.	60	M	8	32,6	21	85	180	-	Meningitis
25.	29	M	9	32	24	50	159	-	Asphixio propt. Aspiratio
26.	57	M	10	31,6	19	78	174	+	Suspensio
27.	40	M	10	30,9	23	80	180	+	Vulnera sclopetaria
28.	42	M	12	27,2	15,7	75	173	+	Schock traumaticus
29.	44	M	13	29,6	24	80	178	+	Schock traumaticus
30.	74	M	13	28,8	21	83	180	-	Schock haemorrhagicus
31.	54	M	13	28,1	16,5	80	179	-	Insufitientio myocardii acuta
32.	53	M	14	28,4	18	75	172	-	Ruptura aneurismae aortae
33.	67	F	14	27,2	20,6	54	151	-	Schock traumaticus
34.	32	F	14	27,5	20	45	166	-	TBC
35.	36	M	15	27	23	75	174	+	Vuln. Schlopet. capitis
36.	60	M	15	25,9	24,4	76	175	-	Schock traumaticus
37.	53	M	15	24,1	23,6	75	180	-	Canalis punctum cordis
38.	37	M	15	24,5	20	80	181	+	Canalis sclop. Cerebri
39.	32	M	16	24	21	73	166	+	Vulnera sclopetaria
40.	37	M	17	23,5	23	95	187	+	Vulnus sclopet. Thoracis
41.	25	M	19	23	19	80	184	+	Schock traumaticus
42.	25	M	19	23,5	22	95	180	+	Schock traumaticus
43.	20	M	19	23	22	85	184	+	Schock traumaticus
44.	24	M	20	22,7	17	75	180	+	Vulnera sclopetaria
45.	75	M	20	22,5	17	70	173	+	Vulnera sclopetaria
46.	34	M	20	22,5	17	76	175	+	Vulnera sclopetaria
47.	31	F	21	22	20,5	65	155	-	Insufitientio myocardii acuta
48.	44	M	22	21,6	21	73	175	+	Contusio pulmonum
49.	24	M	24	21,3	20	80	178	+	Intoxicatio cum opiati
50.	58	M	24	21,8	21	60	163	-	Contusio cerebri

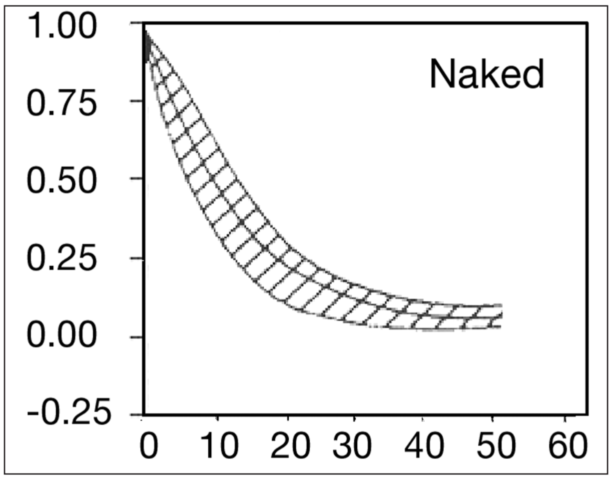


Figure 1

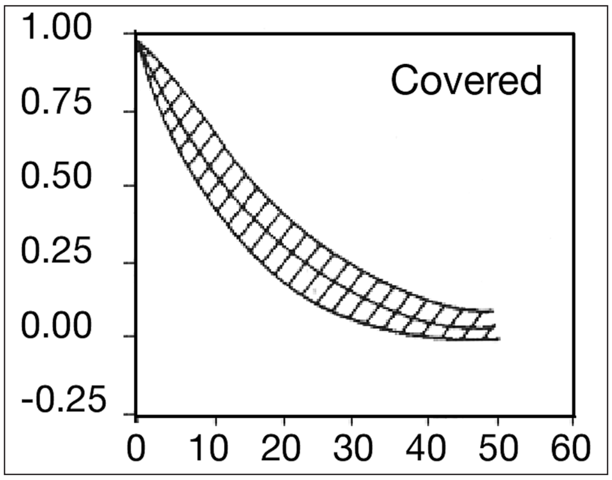


Figure 2

Postmortem cooling of the body is one of the important parameters upon estimation of time since death. Body cooling is a complex issue and it is difficult to estimate the time since death based on it, due to the fact that there's a variety of circumstances that have impact on it: body volume; body surface; body position; covered/naked body; environment temperature and the medium.

Objective

Estimation of time since death through postmortem body temperature can be performed by several methods, i.e. formulas of various authors.

The objective of this paper is to carry out a detailed analysis of some of the existing methods, compare preciseness of obtained results and identify which method is more reliable (precise) in estimation of time of death.

Materials and work methods

50 cases have been analyzed in this paper, autopsied at the Institute of Forensic Medicine and Criminology - Faculty of Medicine, Skopje, with known time of death.

For the needs of analysis, following have been recorded: time of death, clothing condition (body covered or naked), sex and age. Then measuring has been done of: body weight, body height, rectal temperature and environment (ambient) temperature.

Data of analyzed cased with known time of death are given below in Table 1.

In order to estimate time of occurrence of death with analyzed cases, four different formulas were applied. Those formulas are of more recent date and used worldwide.

1. Method 1:

TSD = t - t1/ 1,5

t = rectal t at the time of death in F°

t1= rectal t at the time t1 in F°

2. Method 2:

TSD = (t - t1) + 3

t = rectal t° at the time of death in C°

t1= rectal t° at the time t1 in C°

3 = average length of temperature plateau in h

3. *Al-Alousi and Anderson:*

RTD = (θ1 - θF1) / (θ0 - θF1)

RTD = Ratio of temperature difference

θ**1** = rectal t° at time t1

θ**0** = rectal t° at the time of death

θ**F1** = t° of environment at time t1

All temperatures were measured in C°, and the ratio of temperature difference has been compared to a rectum cooling curve, upon which different rectum cooling curves have been used, depending on the fact whether the body was naked (Figure 1) or covered (Figure 2).

4. Henssge Nomogram

Nomogram method is based on a formula which follows the sigmoid shape of the cooling curve. This formula contains two exponential parts. The first represents the post mortem plateau and the second constant shows the exponential drop of t after the plateau according to Newton's law on cooling.

Using previously announced data stating that relative length of postmortem plateau depends on the t of the environment, Henssge made two nomograms, one for below 23°C and the other for above 23°C. Figure 3 shows an example of its use. In the nomogram there is an addition for the impact of ambient temperature over the speed of cooling and the impact of body weight.

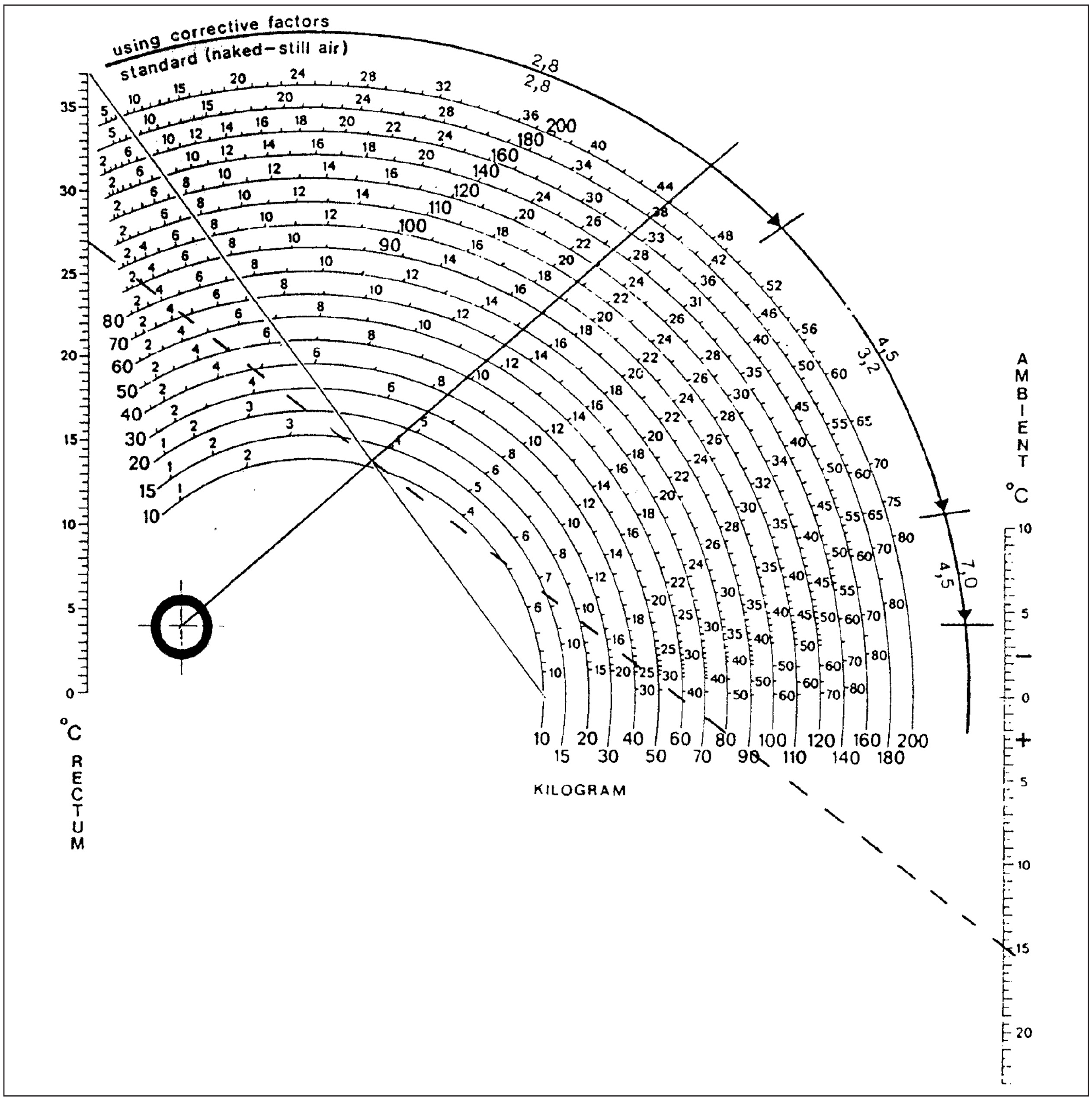


Figure 3. An example of estimation of possible time of death

Results and Discussion

Method 1

After calculation of possible time of death after Method 1, the obtained discrepancies from the true time of death in hours are shown in Graph 1

From Graph 1 it can be seen that obtained values by Method 1 (in hours) on possible time of death, are in most cases less than the true time of death from –0.2 hours to –5.8 hours. Only in two cases (cases nos. 15 and 37) the obtained values have been bigger than the true time of death (+0.7 and +0.5 hours).

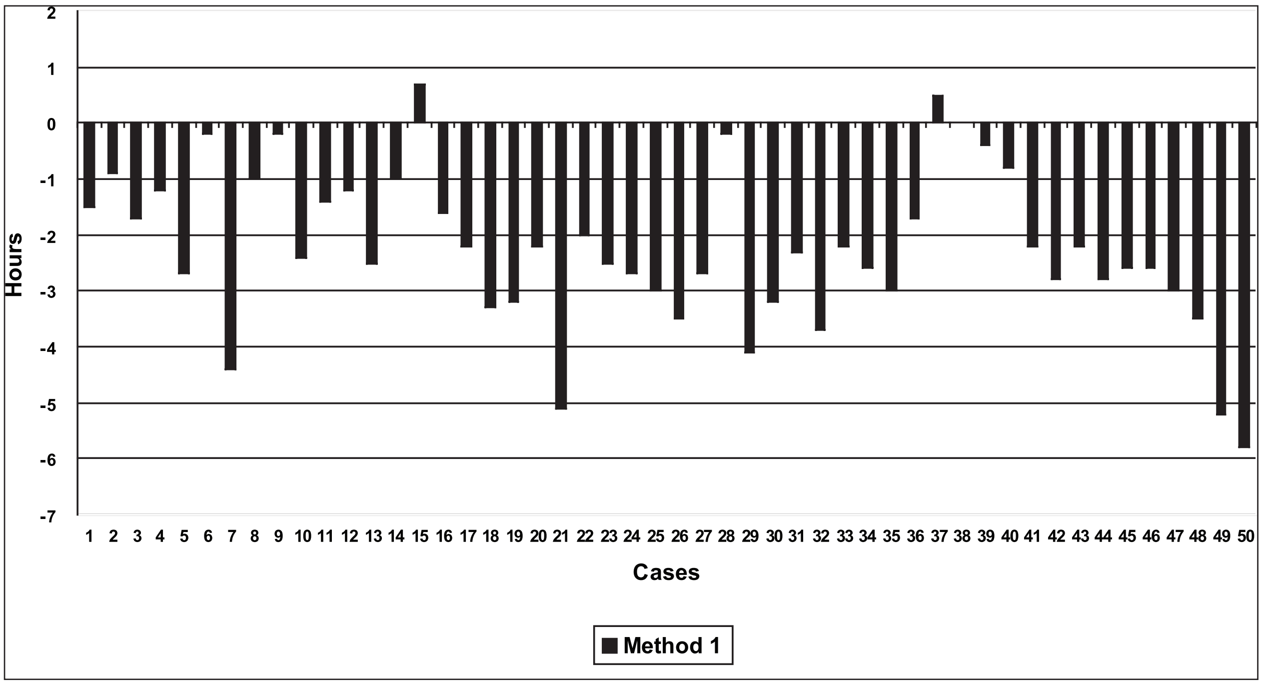
Negative discrepancies, i.e. the values of possible time of death less than the true time of death, result from the fact that in Method 1 post mortem plateau has not been considered, as well as other factors that have impact over body cooling, e.g. the ambient temperature, covertness of body etc.

Method 2

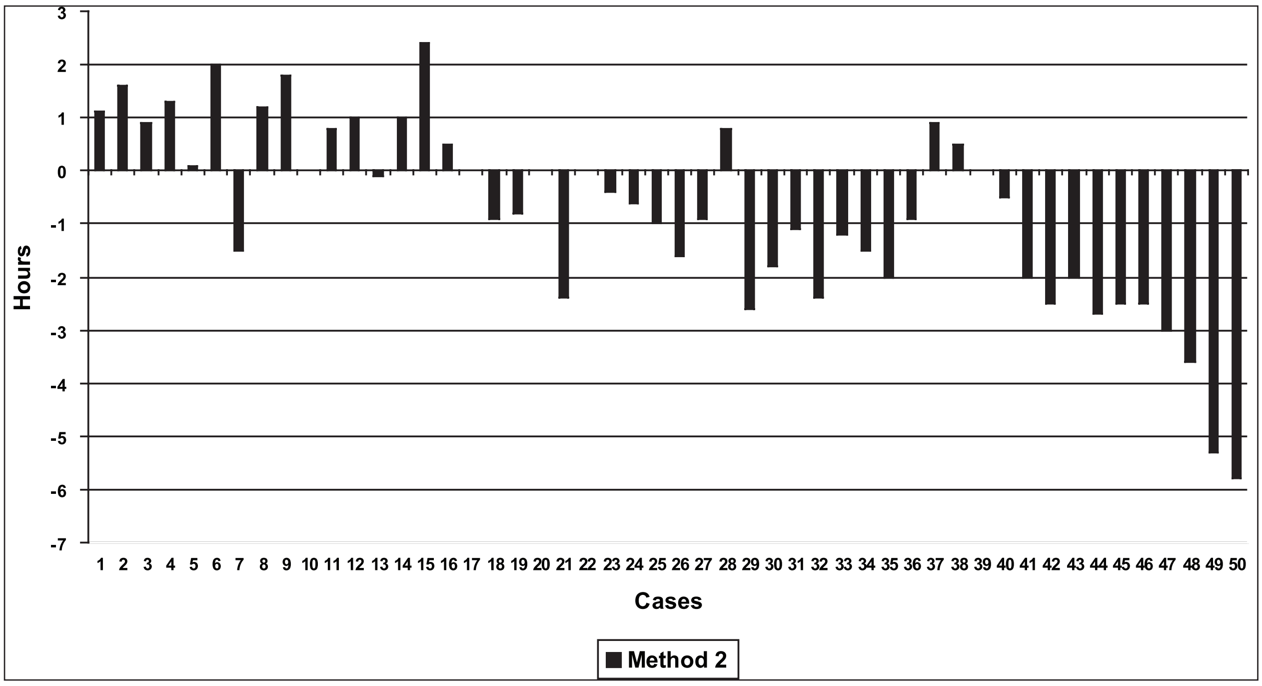
After calculation of possible time of death after Method 2, the obtained discrepancies from the true time of death in hours are shown in Graph 2

From Graph 2 it can be seen that the discrepancies from true time of death are within the range –5.8 to +2.4 hours. Discrepancies for shorter postmortem period, from 4 to 10 hours vary between –2,4 to +2,4 hours and those for postmortem period of 10 to 24 hours vary in the range of –5,8 to +0,9 hours.

Largest discrepancies from the true time of



Graph 1. Discrepancies obtained by Method 1



Graph 2. Discrepancies obtained by Method 2

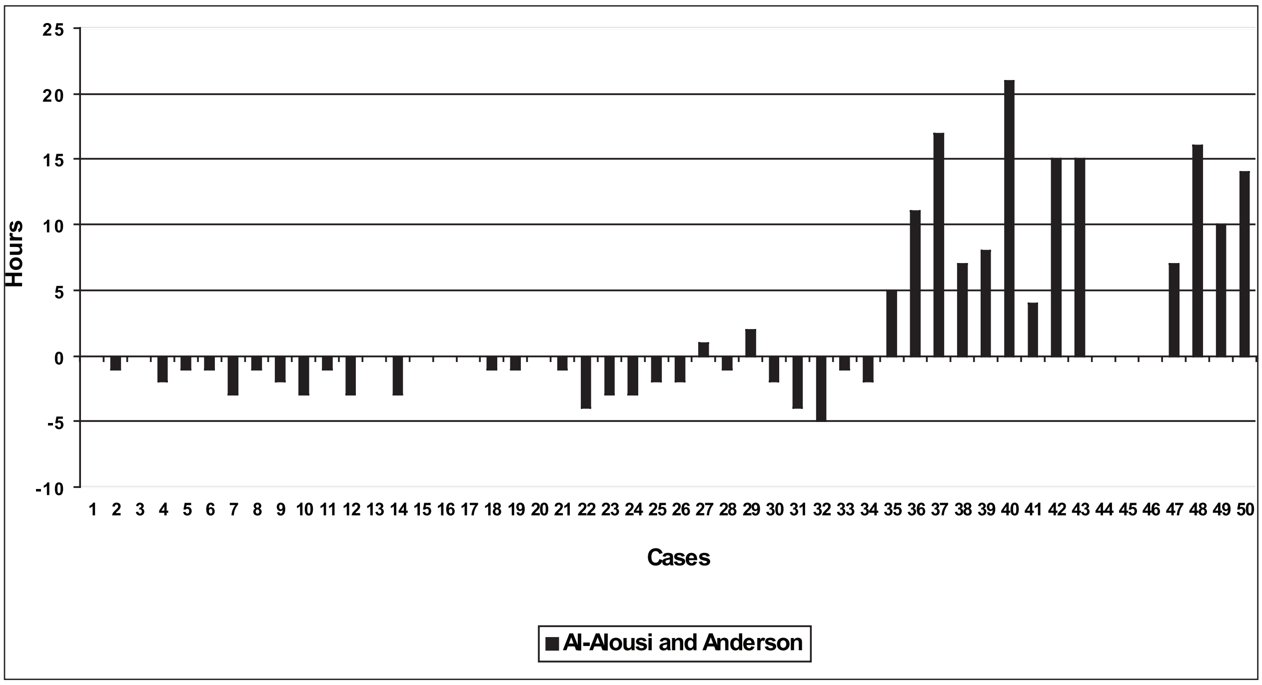
death were the negative discrepancies upon postmortem period of 24 hours (–5,3 and –5,8 hours). Also, it was obvious that when applying Method 2 with five cases there were no discrepancies (cases nos. 10, 17, 20, 22 and 39).

Largest discrepancies from the true time of death are the negative discrepancies upon postmortem period of 24 hours.

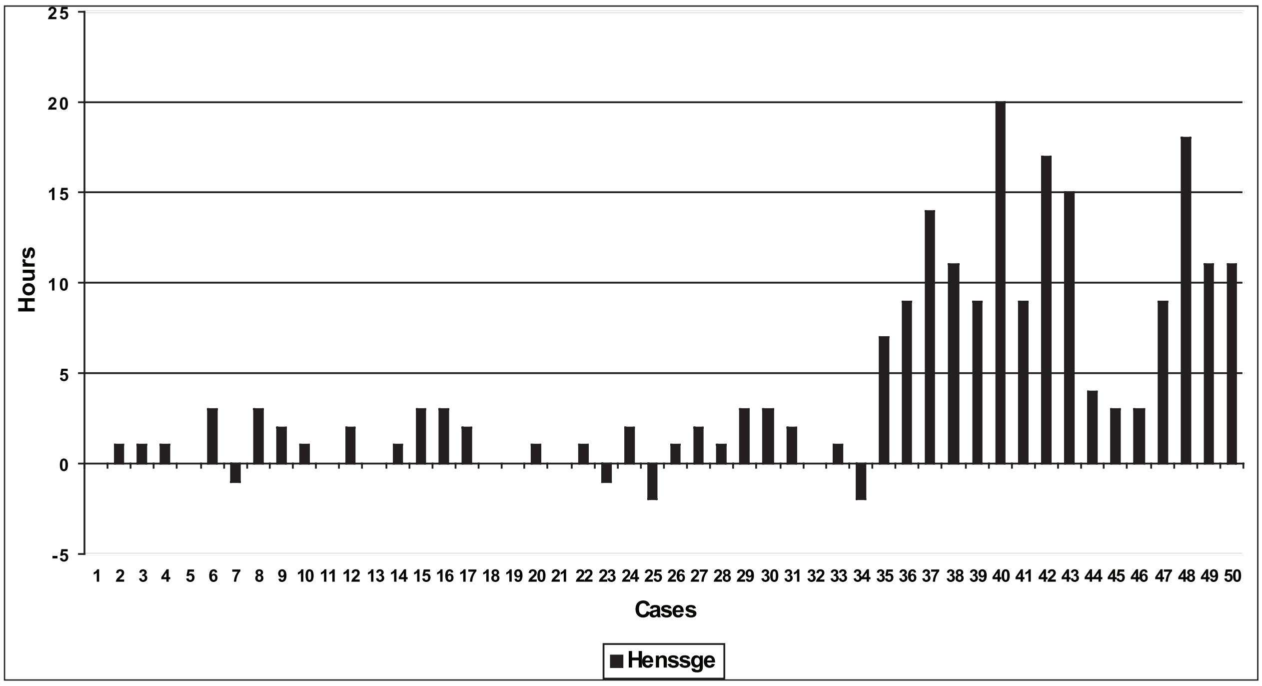
In Method 2 the post mortem plateau was taken into consideration and discrepancies occured as a result of other factors that influence body cooling and which have not been considered by this formula (ambient temperature, body weight etc.).

Method Al-Alousi and Anderson

Results of obtained estimation of possible time of death after the Method of Al-Alousi and



Graph 3. Discrepancies obtained by Al-Alousi and Anderson



Graph 4. Discrepancies obtained by Henssge

Anderson show discrepancies from the true time of death, as presented in Graph 3.

Analysis of obtained results shows that discrepancies from the true time of death vary between –5 to +21 hours. With shorter postmortem period of up to 8 hours, discrepancies range from –3 to +1 hours, and with longer postmortem period they are bigger, i.e. from –5 to +21 hours. Yet, if we look in Table 1 we can see that the biggest positive discrepancies from +11 to +21 hours occur with cases where rectal temperature and ambient temperature are very close, i.e. when temperature difference between the two is about 1 °C. It is also obvious that with cases nos. 44, 45 and 46 (postmortem period of 20 hours), where there was difference between the rectal and ambient temperature, there is no discrepancy from the true time of death.

From Graph 3 it can be seen that by using the Method of Al-Alousi and Anderson with 10 cases, there is no discrepancy from true time of death (cases nos. 1, 3, 13, 15, 16, 17, 20, 44, 45 and 46).

The Formula of Al-Alousi and Anderson includes the parameter covertness of body, yet gives big discrepancies with cases that have close rectal and ambient temperatures.

Henssge Method

Estimation of possible time of death after the Henssge Method represents an estimation by a nomogram which includes temperature plateau, ambient temperature and body weight.

Results obtained by the Henssge nomogram show discrepancy from true time of death as shown in Graph 4.

Analyzing obtained results, it was observed that discrepancies from true time of death have been less (from -2 to +3 hours) with postmortem period up to 15 hours. When postmortem period increases above 15 hours, discrepancies from true time of death are bigger and range between +7 to +20 hours. This refers to cases nos. 35 - 50, but we must consider that with these cases the differences between the rectal and ambient temperatures were very small, i.e. about 1°C. Cases nos. 44, 45 and 46 are exceptional - discrepancies for postmortem of 20 hours was +3 and +4 hours, but here we had bigger difference between rectal and ambient temperatures. From Graph 4 it is possible to see that with a total of 8 cases (cases nos. 1, 5, 11, 13, 18, 19, 21 and 32) there was no discrepancy of obtained possible time and the true time of death.

We can conclude that by Henssge Nomogram which includes the postmortem temperature plateau and the effects of ambient temperature and body temperature over body cooling, best results have been obtained, i.e. discrepancy varied between –2 to +3 hours. Henssge nomogram cannot be applied with cases where rectal and ambient temperatures are close in value.

Conclusion

Estimation of possible time of death by using all four methods shows that preciseness of results depends on the length of postmortem period. Mainly discrepancies range between ± 3 hours. With cases of longer postmortem period, applying Method 1 and Method 2, discrepancies found are up to 6 hours, and by the Al-Alousi and Anderson Method and Henssge nomogram discrepancies have been found less, of ± 3 hours but only in cases where the difference between the rectal and ambient temperatures is several degrees.

It is impossible to estimate possible time of death by Al-Alousi and Anderson Method and especially by Henssge nomogram in case there is only small difference between rectal and ambient temperatures, i.e. when body temperature has approximated temperature of environment, because it results in big discrepancies.

On the basis of obtained results it can be concluded that in estimating postmortem time interval for cases where more of 15 hours have elapsed, results cannot be considered reliable. Henssge nomogram and Al-Alousi and Anderson Method show relatively better results as compared with the first two methods but they are also useless in cases of approximated rectal and ambient temperatures.

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