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PhD THESIS

TIME SINCE DEATH AND BODY COOLING:
REVALUATION OF THE HENSSGE NOMOGRAM

S.S.D. MED/43

Supervisor: Prof. Franco Tagliaro

Tutor: Prof. Domenico De Leo

PhD Student: Elena Pellini

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ABSTRACT

Temperature up corpses along with rigor mortis and the hypostasis, are the classic triad of so-called thanatochronological data. As it is well known, these variables have a key role, for the reconstruction of the time of death. As regards the temperature, by the end of the nineteenth century was introduced to measure rectal, flanked by other venues such as detecting external acoustic meatus, trachea, etc. axillary cavity. The data thus obtained are usually evaluated with different equations for calculating post-death interval (PMI) and then the time of death. Today, the equation most used is that proposed by Henssge, which takes account of temperature and body weight, ambient temperature, clothing worn, ventilation. Paradoxically, few experimental tests of the accuracy of the estimates obtained using this method is available in the literature. The purpose of this study was the assessment of the reliability of this method, in terms of accuracy of the estimate, applied to a series of traumatic deaths with known PMI.

The present study included 46 cases (12 females and 34 males) of death from traffic accident with PMI ranging from 2 to 44 hours. The measurements were performed between January 2008 and December 2010, with 15 cases collected during the cold season (Autumn-Winter) and 31 in the warm season (Spring-Summer). The temperature was measured by inserting the probe metal corpse of the digital thermometer HD2107.2 [Delta Ohm, Boxes Selvazzano (PD)] in the rectal ampulla at a depth of 8 cm. In order to verify the precision of the technique, the measurement was repeated 6 times in the space of 6 minutes keeping the probe inserted in the rectum. The ambient temperature was also measured with same instrument.

The data obtained were recorded along with variables such as clothing, sex, age. In order to reproduce the typical situation of a judicial spot where the body can not be weighted, the weight was assessed on the basis of stature and muscle distribution. Using the Henssge nomogram the after-death interval was calculated then compared with the real one. The actual influence on the estimation of PMI exerted by the various correction factors (clothing, weather conditions, etc.) proposed by the author was also tested.

In all cases, the relative standard deviation of the temperature values in the 6 repeated measurements was < 0.05% confirming the precision of the technique.

Comparing the PMI data calculated by the equation of Henssge with the real PMIs, in 17% of cases the two PMIs coincided with a tolerance of 0.5 hours, in 52% of cases the real PMI fell within the range calculated by Henssge's equation, whereas in 31% of cases the real PMI was outside the range calculated.

Taking into consideration the difficulty in the real cases of assessing the ambient temperature, subject to changes over time, and the uncertainties about the influence of the different situations where the body can be found (in air, on soil, immersed in water), we attempted to evaluate the change of body temperature independently of environment temperature, using for all the cases temperature "standard" values (20°C and 25°C, respectively). However, this approach increased the inaccuracy of the results.

Another relevant factor for the calculation of PMI is represented by the body weight, being the speed of cooling directly depending on the fat percentage and distribution. However, at it is well known, is often impossible to measure the body weight at the crime scene. On this basis, we attempted to calculate the PMI using for all the cases different standard weight values (90, 80, 70, 60 Kg). By using this approach the accuracy of the PMI estimate was acceptable only if the difference between the real weight and the standard value was < 10 kg. In the last step we analized the difference between 2 groups: in the first (23 corpses) we made only one determination; in the second (23 corpses) it were at least two determinations on the corpses. The comparison between the two groups highlighted the importance of repeated measurements to demonstrate the performance of the cooling.

The data obtained until now shows that the accuracy of the estimates varied in relation to time elapsed since death, with a progressive deterioration with the increase of PMI intervals.

In the present study, although performed on a limited number of cases, the exact match (± 0.5 hours) between real PMIs and calculated according Henssge has been restricted to a few cases (17%). On the other hand, taking into account the confidence intervals proposed by Henssge, a "assessment within range" was observed in 70%. Be noted, however, the wide margin of error allowed (between ± 2.8 and ± 7 hours).

The method is more accurate when applied within ten hours after death, when the percentage reaches 33% exact correlation.

INTRODUCTION

Thanatology is a branch of the forensic medicine used to the study of the phenomenon of death and the changes which must meet the corpse (12). The application of the theory on the real case allows the forensic pathologist to answer key questions on when the death occurred and the causes thereof.

The importance of estimating the time since death must have been appreciated for centuries. The community infact have correlated the location and movements of the prime suspects with apparent time of death to test what would later become the defence of alibi. This may have other implications in civil law: it is not only the defence of alibi that has suc relevance to the estimation of the postmortem interval in criminal deaths. The best estimate of time of death forms a primary screening procedure to eliminate some putative killers who could not have access to the deceased at the material time and may strengthen suspicion agaisnt other whose movements coincided with the estimated time.

There are many different methods as each correlated with a precise scope and can be used depending on the greater or lesser period of time has elapsed since the time of death. It should also be noted that along time since the death will be an increasing inherent margin of error in dating.

Should not be forgotten as a role can be pursued in the context of violent deaths, the survival of the victim than at the time of injury: for this purpose are useful histopathology of any injuries in order to detect any inflammatory infiltrates.

That usually characterizes the approach to forensic analysis of dating is the study of the progress of abiotic phenomena. As natural, it is to know as prerequisite the initial value of the data itself and its process of change.

In estimating the time of death are usually analyzed corpse cooling, rigidity, hypostasis, mechanical and electrical excitability of skeletal muscle, ionic concentration humor vitreous other body fluids, and extent of degradation of the wildlife. is not to be forgotten as each of the factors mentioned above affected by natural changes in the environmental conditions in which the body remains.

On the basis of hypostasis, PMI can be estimated in wide range of time, because of the variation of migrability that can occur up to 6-8 hours after death (relative) or up to 12-15 hours after death (absolute fixity).

Also on the basis of rigor mortis estimation of time after death is not reliable because it starts 2 hours after death, evident up to 12 hours ahnd decreases after 36 hours (1).

Of all the methods that thermometer is characterized by many positive aspects that favor the choice than others. These features are related both to the practical aspects (easy, reproducibility of the relief, cadaveric weight measurement) and theoretical (processing a temperature in the living standards, assessment and knowledge of the physical phenomena of heat loss, availability of theoretical models recognized).

Among these, the most currently used was developed by Henssge through a double exponential nomogram where was fixed a parameter z related to the weight and a parameter p for the enviromental temperature.

THE PROCESS OF COOLING AND TEMPERATURE MEASUREMENT

PHISIOLOGICAL ASPECTS

Normally the temperature within the oral cavity is between 35,9 and 37° C while the rectum has an average value of 36,9° C. Therefore it becomes difficult to consider a universal value of normal temperature because of individual susceptibility seen for example in patients with shift work or by the effects of jet lag.

In the literature describes a number of factors that influence the body temperature: metabolic disorders, emotional stress, fever, peripheral circulatory disorders, prolonged exposure to cold environments. do not forget, however, the variability caused by age of the subject: compared with adult children have a normal temperature up to 38° C (14).

It exist a specific thermoregulatory system that in newborns and premature infants, for example, is not independent.

This system consists of thermoreceptors that monitor skin temperature and deep, the hypothalamus (which get information from peripheral thermoreceptors send notice to the effectors (which in turn produce or dissipate heat). Finally certain drugs modulate the thermal regulation as well as exposure continued in the sun.

PHISICAL ASPECTS

The cooling process is governed by specific physical phenomena as conduct, convetion and radiation.

The conduct involves solid objects and is the propagation of the air, without moving the subject, as a result of direct contact. then easily be deduced that the fact that a body rests on a good conductor such as metal or marble than a poor conductor such as wood or mattress goes to change the speed of cooling.

Convection instead occurs with heat transfer between solid and fluid motion in relation to natural or forced (by ventilators) of the fluid.

Another factor to consider is the thermal insulation produced by the clothing or the total thermal resistance between the skin and the outer surface of clothing. It is expressed as a "cycle"with a value between 0 (for the naked bodies) and 3-4 (for clothing polar).

Into the remaining life (14) of the tissue also occurs anaerobic metabolism with production of heat. The main source of this energy is the anaerobic glycolysis whereas a man of average size of about 70 Kg is arguably the basis of glycogen of 0.35 Kg whose hydrolysis generates about 880KJ.

TECHNICAL ASPECTS AND STATE OF THE ART

During the nineteenth century have followed a series of studies of cadaveric temperature measurement. In each of them the most frequent site registered was the armpit or oral. over time, however, the researchers understood as a site deeper could give more useful information. Authors such as Wilkes and Taylor measured the temperature on the outer abdominal surface by an clinical thermometer. That, despite the external factors that could influence the outcome, showed a decrease in temperature gradient difference between external and internal area of the body.

The internal temperature of the body was then identified in the rectal temperature.

Against this theory by authors such as Mead and Bonmarito who showed that living in the temperature varies from place to place depending on the greater or lesser extent on the proximity of the site of large pelvic veins. however, this limit was not considered on the basis that the loss of blood circulation rapidly reduces the temperature gradient between neighboring points. (3)

It has been so recognized as a valid measurement site the rectal at which the liver can be replaced assuming a sexual assault or if don't appear easily accessible. Otherwise, it insert the thermometer to adeguate depth (6-8 cm), keeping it in the case of measurements in sequential.

Other authors have suggested the use of brain or headset temperature. The first, although less influenced by factors such as body size, requires a far more invasive access through the superior orbital fissure. In the latter case, valid for enviromental temperatures between 16 and 23 degrees Celsius, the tympanic temperature is obtained as the average of the two contralateral estimating the time in minutes after death. Actually this method also disregards the clothing: however, that must be taken into account the hair simple and despite easy to use, often results in perforation of the eardrum. (7)

At the same time other scientists showed an increase in the cooling bodies of victims of massive hemorrhage. Thanks to Harry Rainy there was the turning point. He first applied to mathematical rules for calculating the temperature by using Newton's law according to which the rate of heat loss suffered by a hot object cools the air, at constant temperature and in the absence of variables such as ventilation and humidity is in relationship of direct proportionality with the difference in temperature between the object and environment and is related to its thermal conductivity.

Through repeated measurements of rectal temperature of corpses he could confirm the existence of an initial decrease in heat content far, through his studies also failed to calculate the minimum time from death. Instead, the authors emphasize that the subsequent decrease in axillary temperature was much more irregular. The Paduan school of the early twentieth century should be instead the result of a study of one hundred dead bodies. Thanks to this experiment because the researchers demonstrated the existence of a first cooling phase decrease of about half a degree per hour followed by an interval of about eight hours with decrease of about one degree and a final step of gradual reduction until equilibrium with the ambient temperature (set at 24 degrees as standard). The latter period was estimated in a period of about 12-30 hours.

With respect to the measurement study of Lyle and Cleveland fifties there was evidence of interesting because through the thermometer from the same patent was possible to detect the temperature of several points (skin of the trunk muscles of the lower limbs, rectum, brain). This fact allowed him to discrimminare the trend of decrease between the various areas while stressing that the districts were relatively uneven skin, the graphic representation of the measures brain appeared almost homogeneous. Other data obtained concerned the fundamental limit on the validity of the measurement with respect to both time of death (not more than 24 hours before) and at equilibrium with the ambient temperature. There was a breakthrough in research with Fiddes and Patten. In fact, the two researchers placed the clear criteria of performance: constant value of ambient temperature and precise measurement range. Concatenated to it Sieller study that compared the human body to a cylinder as the heat loss diimostro happen according to a gradient between the surface and the inner portion (10). Shapiro developed the concept of a plateau giving a duration of 4 hours. This plateau was due to a delay in the development of thermal gradients with heat loss by conduction to the center of the body surface area and a second phase of this dispersion in the atmosphere. Some authors as Fidden integrate that theory showing how likely not organic metabolic processes are interrupted dramatically after the death of a subject with a good time while continuing to produce heat that maintains the plateau phase.

Beyond the time since death, there was a slow decrease of temperature, slower than that proposed by Newton's law. Newton's law the amount of cooling is proportional to the difference in temperature between the surface of a hot body and the surrounding medium temperature.

To change this trend more variables such as temperature mortis, ambient temperature, weight corpse, proved in fact a direct proportionality between body weight and duration of the plateau.

For this purpose was developed a mathematical formula

$$Tr\,(t) - Ta = B \exp(-Zt) + (C/Z-P) \exp(-Pt)$$

taking into account the temperature of the corpse and environmental as well as latency time between death and measurement described a so-called factor Z (equal to the coefficient of cooling the body according to the ratio between surface and ground).

Umani Ronchi Italian researcher has the merit of having prepared in 1989 a heat loss curve in which taking into account rectal temperature and different time points, he obtained a standard temperature decrease: about ½ degree in the first 3-4 hours, about 1 ° C in the next 10-12 hours, 7-14 hours for other progressively ¾ of a degree ½ degree, ¼ of a degree until it reaches enviromental temperature in a period of 20 to 30 hours. (14)

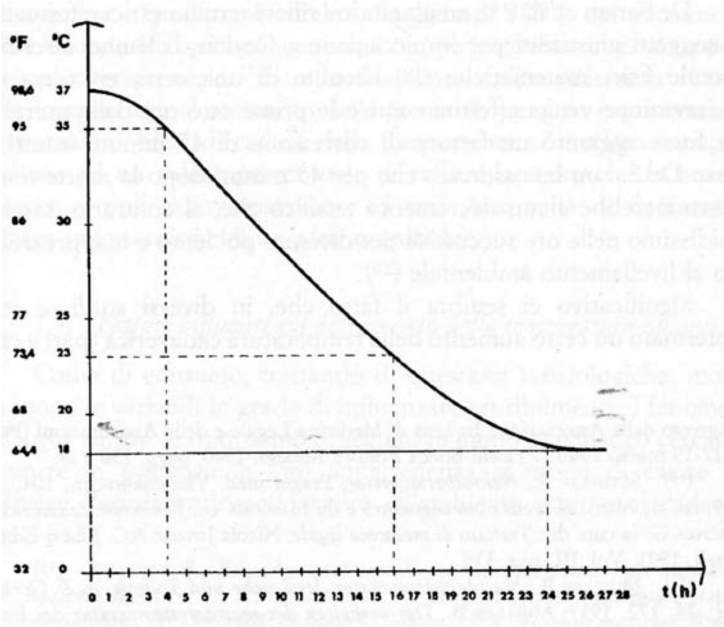


Fig n. 1. Heat loss curve proposed by Umani Ronchi

One of the modern study considered diriment for the analysis of cooling curve and the factors that influence the course, was conducted at the Department of Forensic Sciences, University of Glasgow, where 117 corpses were examined (between 30 and 90 years with a distribution of one third of women's bodies). This research was intended to assess the factors going to affect the cooling and the real validity of previous studies. (10-11)

Every body was stripped, weighed and measured. cases were first divided into subject naked and covered. additional rating covered the body weight varies according to the Z factor corresponding to the BMI. according to this criterion a cadaver was inserted into the group of lean with a Z value greater than 0,028.

Basis of the analysis became evident in the inverse relationship as between the Z factor and the distinction so that bodies skinny-fat overweight showed a Z value less than lean body. Seemed to be a correlation between those variables and body cooling, but nothing could be used in the absolutist sense: in fact, despite 20% of bodies has a rectal temperature lower than many thin body, the remaining cases (33 or 44%) showed a trend unaffected by the cooling body. Was also created a comparison between the actual measurements liver, rectal and brain in relation to two distinct groups, naked and dressed by analyzing also the plateau. Then showed that the plateau was detected only in 22% of cases.

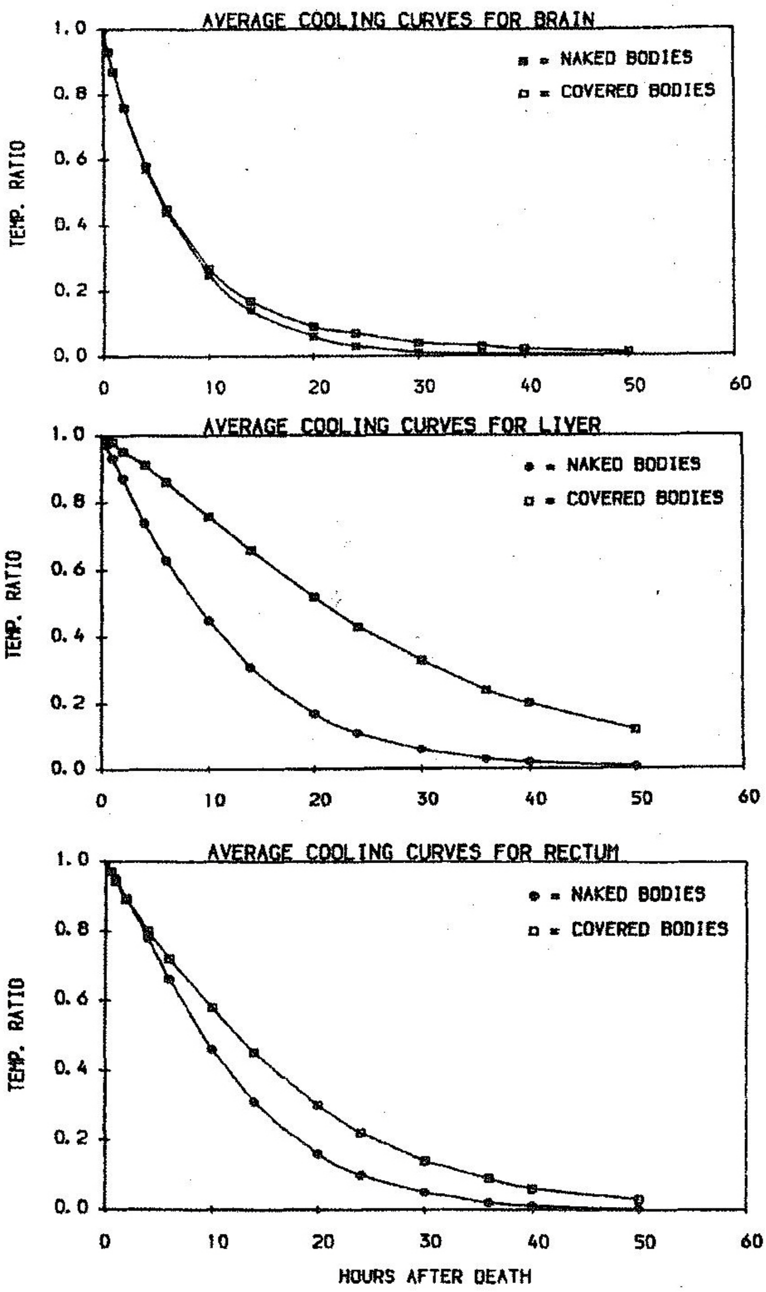


Fig. n.2 Cooling curves of the brain, liver and rectal in the two study groups (naked and clothes)

HENSSGE METHOD

The real revolution in the study of cooling was achieved with Henssge who was responsible for analyzing the development of the famous factor Z. In fact, in contrast to what the others supported, the researcher explained how this factor did not depend so much on the ratio between body surface area and mass as the weight of the individual.

This deduction was obtained following the dictates of Max Rubner which states the proportionality between surface and body weight raising to a rated equal to 0.625.

Z appeared to be equal to -1.2815 (m) 0.625 + 0.0284.

Henssge devised an experiment in which the human body was represented by a cylinder of precise size (19 cm long, 38 cm in transverse diameter, 50 cm in longitudinal diameter, weighing 31 kg). In order to ensure heat dissipation is similar to the real materials were used such as water, agar gel, glycerin and natural rubber. About 10 cm depth was added on thermometer thus exposing the model to various and different environmental conditions. Using the constants of Marshall shows how inclusion of at least 8 cm within the rectal ampulla tool, the temperature was about 37,2° C. To modulate the different variables come into play cool environmental conditions and physical structure. So it was that the researcher was able to differential by two distinct temperature ranges the environmental analysis of the cooling corpse: up to 23 ° and beyond 23 °. So it was that you could create the final equation in place of which you could otherwise use the nomogram. (12)

There are represented two scales, for rectal and enviromental temperature, being in possession of these two facts, draw a straight line joining the points of two scales. Then you go to cross the diagonal of the nomogram and pulls a second line from the center of the circle crosses the previous point (created by the intersection between straight and diagonal).

Being so aware of the value of body weight (or at least an estimate thereof) you will read the corresponding value indicating the number hours spent by death. What will be provided will not be an absolute value but added temporal gap within a range in excess or defect of 2,8 / 3,2 / 4,5 / 7 hours.

Henssge stressed right away how they should be taken into account the environmental variables and physical of the person creating the correction factors to be applied for the estimation of death of corpses are not exposed to standard conditions. These correction factors involving the clothing of the corpse (with the scale and possible humidity) as well as the ventilation conditions and presence of permanent water in the body. (9)

Given the important point of measurement corpse clothing of most interest are those of the lower portion of the trunk.

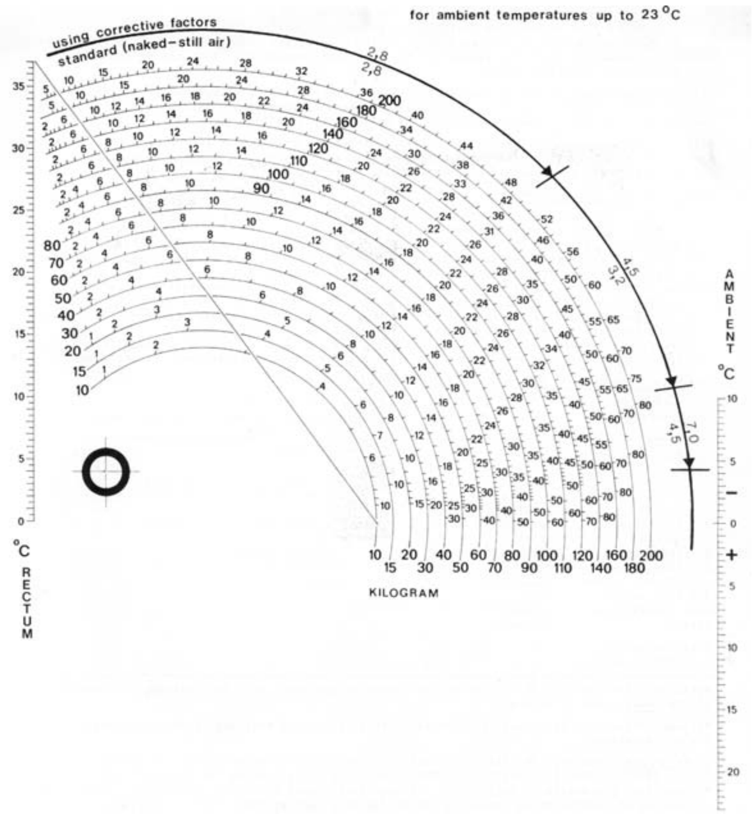
There are limits, Henssge professed by himself, to use the nomogram and headed to the whereabouts of the corpse (if different from that where the death occurred), the exposure of the body to very sunny or artificial ventilation as well as cooling situations with unknown dynamics.

Henssge later continued his studies in order to make more reliable method, especially by tackling correction factors. In 1992 the author, using cooling dummies with different weights, has made a series of experiments as a result of which has come to make the equation.

$$F = \{- \frac{1.2815 / [(kg – 0.625) – 0.028] [- 3.24596 \exp (- 0.89959 F_{70})] – 0.0354}{Kg}\} 1.6$$

Hennsge specific however, as this method was particularly useful if you need to change the correction factor for body weight very far from the standard 70 Kg.

In 2000 Finally Henssge studied 72 cases applying the nomogram as a primary method, and then considering other parameters (hypostasis, stiffness, excitability of skeletal muscle mechanical and electrical and chemical excitability of the iris). These additional criteria were useful for modifying the uncertainty intervals calculated with the nomogram. Henssge then worked out a software that can calculate the time of death using data on the ambient temperature and cadaverous, the correction factors, the observation of envy and rigor, the excitability of skeletal muscle (mechanical or electrical) and the chemistry of the iris.



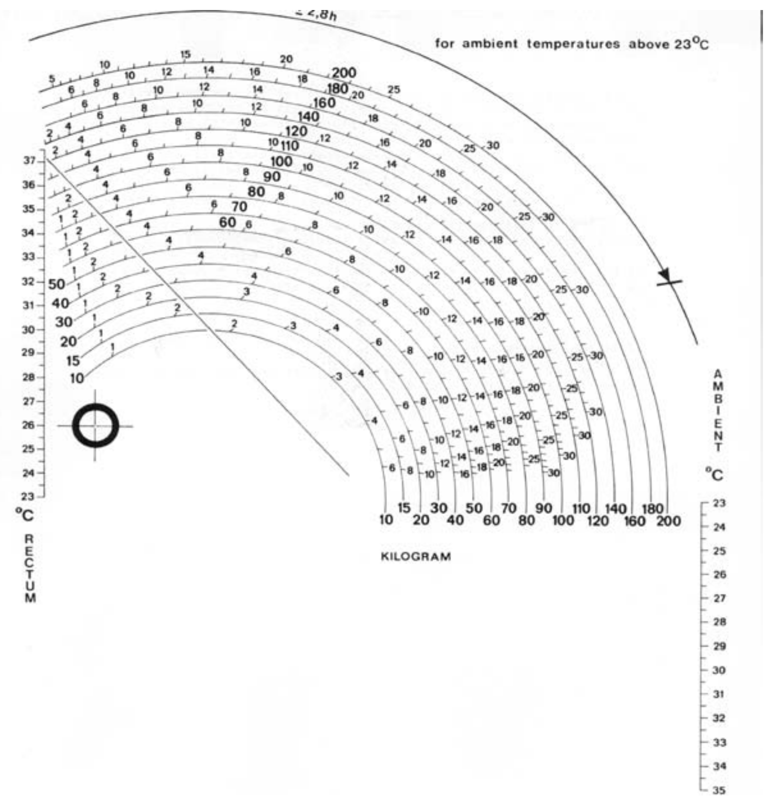


Fig. 3 Henssge nomograms for enviromental temperature up to 23°C (upper) and above 23°C.

Table n. 1 Corrective factors proposed by Henssge

Dry clothing/covering	**In air**	**Corrective factor**	**Wet through clothing/covering wet body surface**	**In air**	**In water**
		0.35	naked		flowing
		0.50	naked		still
		0.70	naked	Moving	
		0.70	1-2 thin layers	moving	
naked	moving	**0.75**			
1-2 thin layers	moving	**0.90**	2 or more thicker	moving	
naked	still	**1.00**			
1-2 thin layers	still	**1.10**	2 thicker layers	still	
2-3 thin layers	Moving or still without influence	**1.20**	More than 2 thicler layers	still	
1-2 thicker layers	Moving or still without influence	**1.20**			
3-4 thin layers	Moving or still without influence	**1.30**			
more thin/thicker layers	Moving or still without influence	**1.40**			
Thick bedspread	Moving or still without influence	**1.80**			
Thick bedspread+clothing combined	Moving or still without influence	**2.40**			

MATHERIAL AND METHOD

In this study we used a series of instantaneous deaths (46 subjects) as a result of an accident.

The decision to analyze only this type of death is justified by the fact of wanting to exclude any pathological condition that could influence initial body temperature as well as the trend of decrease.

The instrument used to measure the temperature is a digital thermometer with metal probe, supplied by the company Delta Ohm Selvazzano.

For each case, we proceeded to measure the temperature of the morgue, the carriage on which the corpse, the cadaveric rectal temperature.

As regards the latter as we tried to standardize the amount of insertion of the probe between the various surveys outlining eight notches along the probe itself in order to insert a length of 8 cm.

Once inserted within the rectal ampulla, we proceeded to turn the instrument on and wait for the calibration.

Once you get the value of the instrument temperature corpse was left in place, off and on again for another 5 times in order to evaluate the different values obtained from these measurements and other measurement reproducibility and thereby obtain a gap of between a hundreth the six measurements.

The series consists of 46 cases (34 males, 12 females), distributed between January 2008 and December 2010. The seasonally allowed to classify 20 deaths in the summer, 12 in autumn, 8 in the spring, 6 in winter. The estimated weight is within a range from 15 to 100 kg with a post-mortem interval from 2 to 44 hours.

Once you get the value of the rectal temperature and environment, it was decided to incorporate these values within the nomogram Henssge thereby obtain the time intervals post-mortem interval. It was considered to give a gap of 30 minutes compared to the real value of pmi ittendendo thus three different possible outcomes: clear correspondence between the two values (real and nomogram), the real value of PMI within the range allowed by henssge, incompatibility of the two values.

The weight of the corpses was assessed on the basis of stature and body constitution.

Table n. 2 Table used in our study

N.	Kg	Clothes	Hs in MR	Hs in F	°C MR	°C R	PMI	H.N.	±	Y/N

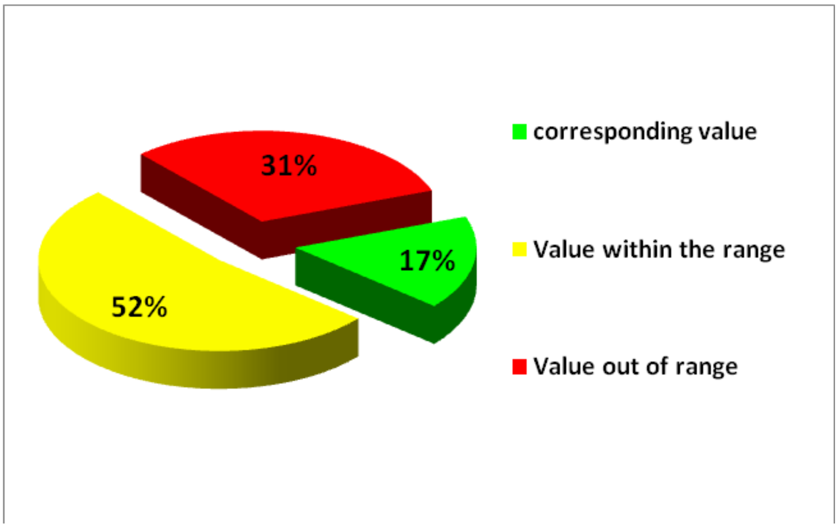
We then proceeded to consider experimental variables such as standard weight and temperature. has therefore made the calculation using the nomogram Henssge temeprature considering a constant environment at 20 degrees and 25 degrees. The estimated weight however was fixed at 60, 70, 80, 90 Kg.

In the second part of the study we divided the cases into two groups (23 subjects each). The group “A” contained cases in which it made only one temperature measurement. Group B contained subjects for which they were carried out at least two measurements.

RESULTS

The total number of temperature measurements between 2008 and 2010 made it possible to detect a rate of 17% of cases in which there was a coincidence between the value of PMI known and PMI obtained by the Henssge nomogram (with a gap of 30 minutes). In 52% of cases, however, although the value does not coincide, provided within the range by Henssge while in 31% of cases there was no correspondence as you can see below.

Fig. n.4. Distribution of percentages in the cases analyzed



Then we tried to analyze the different distribution between the sexes. Although the two samples are not homogeneous among them (34 males and 12 females), it became clear, however, as in males was higher the number of cases of perfect coincidence between the two values of PMI.

Table n. 3 Distribution of percentages between females and males

	Females	Male
Corresponding value	8,3%	19,70%
Value within the range	58,3%	50,00%
Value out of range	33,40%	30,30%

Table n. 4 Complessive data obtained

N.	kg	Clothes	Hrs in MR	Hrs in F	°C MR	°C R	PMI	HN	±	Y/N	I.C.F
B.M.	80	+++	21		20,74	28,5	21,5	23,0	4,5	Y	10Kg
C.O	80	+	22,5		19	28,95	22,5	16,0	2,8	N	30Kg/ 25°C
T.M.A.	80	+++	22,5	4,5	17	27,39	27,0	21,0	2,8	N	50Kg
V.A.	60	+++	23		19,93	29,81	25,0	14,0	2,8	N	80Kg
M.A.L	60	+++	14,5		20,4	28,23	14,5	18,0	4,5	Y	0Kg/ 20°C
V.O.	100	+	12		20,76	32,57	14,0	12,5	2,8	Y	10Kg
T.G.	60	++	39	5	19,02	21,2	44,0	46,0	7	Y	15Kg
L.M.	70	+	21		20,1	26,82	21,0	19,0	3,2	Y	10Kg
M.R.B	70	+	13		21	33,48	13,0	7,0	2,8	N	50Kg
J.M.	15	+	13		21	22,82	13,0	11,0	4,5	Y	2Kg
F.M.	30	+++	14		20,56	35,52	14,0	4,0	2,8	N	170Kg
N.M.	20	+++	14		20,56	31,8	14,0	7,5	2,8	N	85Kg
A.M.	80	+	13		21	30,05	13,0	16,0	2,8	Y	-15Kg
D.D.	60	++	17		18,31	27,41	18,0	18,0	4,5	Y	20Kg
R.M.a	60	+++	14,5		17,8	24,45	17,0	24,0	4,5	N	-5Kg
T.M.	80	+++	3		21,5	34,46	3,0	10,0	2,8	N	-50Kg
T.M.	80	+++	7,5		21,14	30,34	9,5	18,0	2,8	N	-30Kg
R.M.b	70	++	9,5		20,68	30,44	9,5	12,5	2,8	Y	-20Kg
Z.D.	70	+++	21		23,44	30,68	21,0	17,0	2,8	N	50Kg
C.M.	80	++	40		22,94	25,26	40,0	38,0	7	Y	5Kg
C.G.	80	+	18,5		23,1	30,09	18,5	15,0	3,2	Y	20Kg
C G	80	+	21,5		23	29,02	21,5	20,0	3,2	Y	5Kg- 25°C
T.C.G.	80	+	5,3		22,61	34,65	5,3	7,0	2,8	Y	-20Kg
T.C.G.	80	+	8,3		22,8	32,8	8,3	10,5	2,8	Y	-20Kg
B.F.	80	+	20		24,73	30,87	20,0	15,0	3,2	N	30Kg
B.F.	80	+	23		24,73	29,85	23,0	18,5	3,2	N	20Kg
B.F.	80	+	26		24,2	28,76	26,0	22,0	3,2	N	10Kg
M.J.P	80	+	7,5		16,9	33,75	7,5	7,0	2,8	Y	0Kg/ 20°C
M.J.P.	80	+	11,5		19,8	30,82	11,5	12,0	2,8	Y	0Kg
M.J.P.	80	+	14,5		17,9	28,6	14,5	15,0	2,8	Y	0Kg
L.D.	90	+	16		24	31,18	17,0	14,5	2,8	Y	25Kg
L.D.	90	+	19		24,05	30,09	20,0	18,0	3,2	Y	10Kg
L.D.	90	+	22,5		24,33	29	23,5	22,0	3,2	Y	5Kg
P.O.	90	+	16		25,01	33,87	17,0	9,5	2,8	N	60Kg
P.O.	90	+	19		24,82	32,85	20,0	11,0	2,8	N	60Kg
P.O.	90	+	22		25,22	31,62	22,0	15,0	2,8	N	40Kg
A.F.	60	+	17		24,54	29,7	17,0	14,0	3,2	Y	15Kg
A.F.	60	+	20		24,57	28,55	20,0	15,0	3,2	N	25Kg
A.F.	60	+	23		25,1	27,6	23,0	21,0	3,2	Y	5Kg
E.M.B	60	+	10		25,1	32,8	10,0	7,5	2,8	Y	20Kg
E.M.B	60	+	12		24,9	31,8	12,0	10,0	2,8	Y	15Kg
E.M.B	60	+	14,5		25,3	30,4	14,5	13,0	3,2	Y	10Kg
E.M.B	60	+	16,5		25,5	29,9	16,5	14,0	3,2	Y	10Kg
E.M.B	60	+	18,5		24,7	29,2	18,5	16,0	3,2	Y	10Kg
A.L.	70	+	3		23,7	35,98	3,0	3,0	2,8	Y	0Kg

N.	kg	Clothes	Hrs in MR	Hrs in F	°C MR	°C R	PMI	HN	±	Y/N	I.C.F
A.L.	70	+	5		24	34,7	5,0	5,2	2,8	Y	0Kg
A.L.	70	+	7		23,9	33,5	7,0	7,0	2,8	Y	0Kg
A.L.	70	+	9		23,5	31,95	9,0	9,5	2,8	Y	0Kg
A.L.	70	+	11		23,5	31,1	11,0	11,5	2,8	Y	0Kg
P.R.	80	+	19,5		18	32	19,5	10,0	2,8	N	70Kg
V.M.	90	+	3		23,6	36,9	**3,0**	2,0	2,8	**Y**	20 Kg
V.M.	90	+	5		23,5	36	**5,0**	4,0	2,8	**Y**	10Kg
V.M.	90	+	7		23,4	34,8	**7,0**	6,5	2,8	**Y**	0 Kg
V.M.	90	+	9		23,4	33,8	**9,0**	8,0	2,8	**Y**	10Kg
V.M.	90	+	24		23,1	28,1	**24,0**	23,0	3,2	**Y**	5Kg
D.V.C	70	+	19		15,3	23,9	**19,0**	19,0	3,2	**Y**	0Kg
D.V.C	70	+	21		15,9	22,5	**21,0**	22,0	3,2	**Y**	-5Kg
D.F.	70	+	2		22,1	36,4	**2,0**	3,0	2,8	**Y**	-10Kg
D.F.	70	+	4		22	35,5	**4,0**	5,0	2,8	**Y**	-10Kg
D.F.	70	+	6		22	34,1	**6,0**	7,0	2,8	**Y**	-10Kg
P.E.	70	+	23		14	21,2	**23,0**	22,0	3,2	**Y**	5Kg
V.J.E.	60	+	6		20,2	32,4	**6,0**	9,0	2,8	**N**	-10 Kg
V.J.E.	60	+	8		20,4	30,8	**8,0**	12,0	2,8	**N**	0 Kg
P.F.	60	+	3		14,6	32,4	**3,0**	6,0	2,8	**N**	-35Kg
P.F.	60	+	5		15,9	31,1	**5,0**	8,0	2,8	**N**	-25Kg
P.F.	60	+	7		17,6	29,6	**7,0**	11,0	2,8	**N**	-25Kg
P.F.	60	+	23		17,7	22,2	**23,0**	27,0	7	**Y**	0Kg
F.G.	50	+	4,5		19,8	35	**4,5**	4,0	2,8	**Y**	25°C/ 0Kg
F.G.	50	+	6,5		20	33,7	**6,5**	5,5	2,8	**Y**	0Kg
V.A.	90	++	19		21,38	29,7	**19,0**	18,5	2,8	**Y**	0Kg
V.A.	90	++	21		21,1	28,7	**21,0**	21,0	3,2	**Y**	0Kg
V.A.	90	++	23		20,57	27,6	**23,0**	23,5	3,2	**Y**	-10Kg
Z.M.	80	++	16,5		21,4	29	**16,5**	19,8	4,5	**Y**	0Kg
Z.M.	80	++	19,5		21,1	27,9	**19,5**	22,0	4,5	**Y**	-5Kg
Z.M.	80	++	22,5		21	26,8	**22,5**	26,8	4,5	**Y**	-30Kg
C.R.	90	+	6		20,7	33,6	**6,0**	9,0	2,8	**N**	+50Kg
C.R.	90	+	22		20,7	31,5	**22,0**	13,0	2,8	**N**	-5Kg
C.M.		++	16		20,6	29,3	**16,0**	18,5	2,8	**Y**	0Kg
C.M.		++	22		20,7	27	**22,0**	25,0	4,5	**Y**	+15Kg
D.D.	80	++	18,5		20,7	29,8	**18,5**	17,0	2,8	**Y**	+15Kg
D.D.	80	++	23		20,8	28	**23,0**	21,0	4,5	**Y**	+15Kg
E.S.	55	+	15,5		22,5	30	**15,5**	13,8	4,5	**Y**	+40Kg
EPA	47	+	12,5		19,1	31,3	**12,5**	14,0	2,8	**Y**	-25Kg
EPA	47	+	16		19,6	21,7	**16,0**	21,0	4,5	**Y**	-20Kg
H.F.	70	+	7		20,9	32,4	**7,0**	10,5	2,8	**N**	-10Kg
H.F.	70	+	10		20,9	30,5	**10,0**	14,0	2,8	**N**	-10Kg
H.F.	70	+	13		20	28,6	**13,0**	17,0	4,5	**Y**	-10Kg
H.F.	70	+	16		20,9	27	**16,0**	22,0	4,5	**N**	-15Kg
P.FF.	60	+	24		20,5	24	**24,0**	25,0	4,5	**Y**	-5Kg
N.R.	80	+	11		22,5	31,9	**11,0**	12,5	2,8	**Y**	-10Kg

DISCUSSION

Observing the table it's clear how this method is too far from the reliability:despite of the large range proposed by the author (2,8 -7hs with average value of ±3,31) the percentage of exactly corrispondence, as 17%, and the percentage of included values 52% allow to considerer the method usefull in two third of total cases.

Trying to “explaining” the limits of the method it's important considerer many variables related with the time, circumstances, place of death and the hours spent in the open air.

On the other hand, Henssge stressed the important role played by the body weight: we didn't weight the corpses simulating an hypotetical situation of crime scene in which we don't have the balance. This simple estimation despite of the precise value could certainly invalidate the results.

In the second step, presuming the reliability of Henssge method and knowing the real PMI and the PMI obtained, we found the individual corrective factor able to create the effective corrispondence between the two series of data. It's strange to note how in some cases it was necessary adjyst so much the weight: the kilograms corresponding the corrective factor ranged from -50 to 170 (with average value of 8,58).

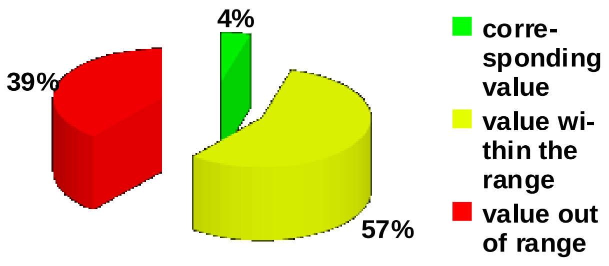
It's interesting to highlight how in many cases of more measurements along the time a lower value of weight was necessary to modify.

In the second phase of the study we divided the data into two equal amounts (23 cases each). The first, group A containing the subjects to a single measurement, the second group B subjects with a minimum of two measurements.

The interval between each measurement and the other varied from case to case basis in relation to the possible availability of the body with respect to clearance from the burying upon arrival at the mortuary.

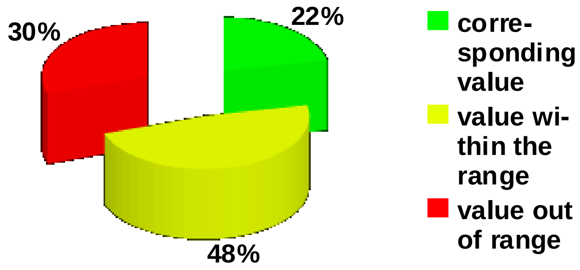
Then analyzing the data obtained in two separate groups with respect to the coincidence or less of the post mortem interval of real and calculated, it is interesting to note that the passage of time is reduced by almost half the exact correspondence of the two values obtained still benefit from range of difference offered by the nomogram.

Fig. n. 5 Different percentage in Group A and Group B (in first and second measurement)

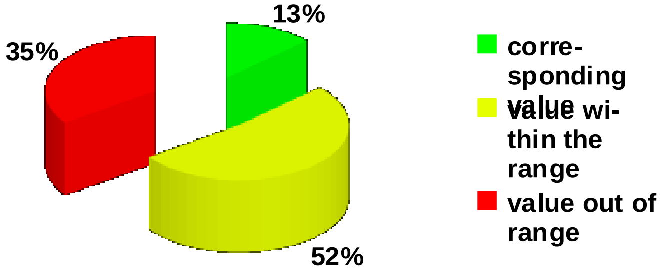


Group A

Group B first misuration



Group B second misuration



HENSSGE NOMOGRAM APPLICATION TO REAL CASE WITH PMI UNKNOWN

Case n. 1

Fig. n. 6 The body as found

The lifeless body of a young man from Marocco was found randomly on the morning of November 14 around 09:30 am in an open space in Caprino Veronese.

The police demanded the intervention of the medical examiner to inspect the body and place of discovery. The death of the subject was classified as asphyxia caused by strangulation.

The body rested on the ground, wearing a sweatshirt fleece, a long-sleeved shirt, pants and socks in the sponge. The body was lying on his back. It therefore proceeded to the detection of cadaveric and enviromental temperature

Table n. 5 Value of temperature measurements

	°C	hs
Air temperature	11,19	11:00 am
soil Temperature	8,83	11:05 am
Rectal temperature	22,55	11:10 am

At 13:00, after the transfer of the body in the Hospital carried out a second survey

Table n.6 Value of temperature measurements

	°C	hs
Air temperature	15	01:00 pm
Rectal temperature	18,04	01:10 pm

In both moments we shall also observe the distribution of rigor mortis and bruises hypostatic. Using the nomogram was obtained Henssge therefore an interval of time of death, equivalent to 17-19 hours before a difference of 3.2 hours. We also run two samples of vitreous humor, at a thirteenth day of November 14 and another at the same time the next day. The interesting data was obtained from the second misuraizone that backdated the death of 45 hours with a gap of about 2 hours.

Case n. 2

Fig. n. 7-8 The bodies of wife and husband. She was on the bed, he has founded in the cellar.

The night of April 24, 2008 the nephew of a married couple found the lifeless bodies of his aunt and uncle in their home. man's body was found in the cellar, on the floor, covered with cartoons and with his hands tied back, wearing a sweater and a pair of jeans. But woman was in the bedroom, lying on the bed wearing only a bra and a shirt raised. During the inspection of the different temperature measurements were carried out both environmental and cadaveric.

Table n. 7-8 Temperature data obtained during the inspection

Female	°C	hs
Air temperature	18,9	3:58
Bed Temperature	20	4:00 am
Rectal temperature	32,01	4:05 am

Male	°C	hs
Air temperature	19,1	4:45
Floor Temperature	16	5:00
Rectal temperature	29,8	5:25

Using the nomogram Henssge with an estimated weight of 60 kg for women, it was possible to place the time of his death in about 10 hours (with standard deviation of 2.8 hours in excess or defect) prior to the survey (conducted at 04:00). As for the husband, compared to 05:00 in the survey by the nomogram was calculated Henssge a PMI of 12 hours (with the same range of difference of 2.8 hours).

This determination was central to the suspect who claimed to be the main author of the only murder of man reporting that the woman upstairs while he was alive and the old man is in the basement.

Case n.3

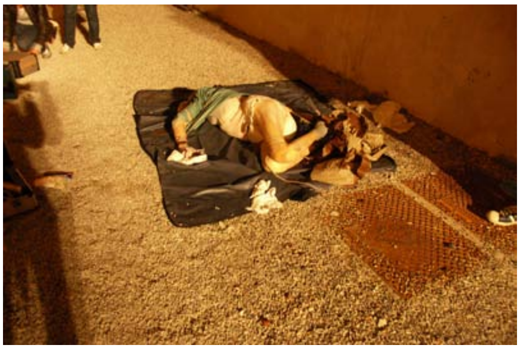


Fig. n. 9 The male body after recovery from water

The night of September 20, 2010 at 23:00 was requested medical assistance office in Peschiera del Garda following the discovery by the waters of the lake, the corpse of an elderly person. The body has hands and feet tied together while back another noose was tied around the neck. muscle rigidity was resolved and the pink hypostasis were distributed along the region of the spine. The skin of hands and feet were soaked. Than the temperature was then carried out the detection of multiple data reported below.

Table n. 9 Temperature data obtained during the inspection

Male	°C	hs
Air temperature	16,7	00:56
Water Temperature	20,5	00:58 am
Rectal temperature	20,4	01:00 am

Using the nomogram Henssge the date of death was traced back to about 35 hours prior to the recovery of the body or by Friday evening. In this case, unfortunately, the analysis of the vitreous humor for quantificaizone potassium was not useful as a comparison with the temperature because the body had remained in the water.

Fig. n. 10 The bodies of wife in the water

The next day, late in the morning, was recovered another body, female, in the same area with similar slurs and distributed along the body surface, with a bag avvotlo around the neck with a rope that joined in the mail around wrists and ankles. The woman wore a dress in synthetic fabric, a tank top, bra and panties. the skin especially handheld was more soaked than that of the corpse the night before. Also in this case rigor was resolved. below reports the enviromental and cadaveric mesaurements made at the time of the inspection.

Table n. 10 Temperature data obtained during the inspection

Female	°C	hs
Air temperature	20,6	01:30 pm
Water Temperature	20,5	01:35 pm
Rectal temperature	20,5	01:45 pm

CONCLUSIONS

The study conducted by this project was to assess the effectiveness of the method of Henssge and above all the variables that affect its reliability. the choice of casistic at PMI known was useful although there are inherent limitations to the potential of research.

These limits are logically related to both temporal and logistical circumstances, both practical factors. On the one hand does not always get information in relation to time spent in the open air of the body after death as the "contamination" caused by the lack of foresight in the management body within the hospital (for example, opening doors, turning on air conditioning). These limits are logically related to both temporal and logistical circumstances, both practical factors. On the one hand does not always get information in relation to time spent in the open air of the body after death as the "contamination" caused by the lack of foresight in the management body within the hospital (for example, opening doors, turning on air conditioning). operating limits for these first you add the issue of body weight also wanting to recreate the situation in fact did not allow the inspection to evaluate the usefulness of the data really accurate nomogram with respect to the conditions dictated by the author (calculation of weight) On the other hand it is equally true that, this guide covers the requirements of the nomogram and seeking a correction of the values obtained using different calibraizone of body weight showed an uncertainty of this variable because in some cases it was necessary to add a lot of weight too away from the real one. Compared to actual cases described above but it seemed interesting to repeat three different circumstances of discovery of a corpse as regards the influence that the body could have suffered from environmental conditions.

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