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The mystery surrounding the time of death: post-mortem findings as an aid for forensic investigation.

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ABSTRACT

A recurring problem in forensic medicine is the need to fix the time of death within the limits of probability. It is self-evident that the longer the interval of time between death and the examination of the body, the wider will be the limits of probability. The longer the post mortem interval, the more likely it is that associated or environmental evidence will furnish more reliable data on which to estimate the time of death than will anatomical changes. Many physico-chemical changes begin to take place in the body immediately or shortly after death and progress in a fairly orderly fashion until the body disintegrates. Each change has its own time factor or rate. Unfortunately, these rates of development of post mortem changes are strongly influenced by unpredictable endogenous and environmental factors. The longer the post mortem interval, the less precise is the estimate of the time of death.

Keywords: Anamnestic, Algor Mortis, Cadaveric, Septicaemia, Adipocere

Background & Introduction

Establishing the time of death

A recurring problem in forensic medicine is the need to fix the time of death within the limits of probability. No problem in forensic medicine has been investigated as thoroughly as that of determining the time of death on the basis of post mortem findings. Apart from its obvious legal importance, its solution has been so elusive as to provide a constant intellectual challenge to workers in many sciences. In spite of the great effort and ingenuity expended, the results have been

meagre [1, 2]. It is self-evident that the longer the interval of time between death and the examination of the body, the wider will be the limits of probability. The longer the post mortem interval, the more likely it is that associated or environmental evidence will furnish more reliable data on which to estimate the time of death than will anatomical changes.

It is necessary to be alert to the possibility that the post mortem interval (the time elapsed from death until discovery and medical examination of the body) may be preceded by a significant survival period (the time from injury or onset of the terminal illness to death). The survival interval is best established by evaluating the types, severity and number of injuries present and the deceased's response to them, taking into account pre-existing natural disease. At autopsy it is necessary to assess the evolution of the inflammatory response and repair process in skin and viscera.

Sources of evidence

Evidence for estimating the time of death may come from three sources:

1. Corporal evidence, i.e. that present in the body.

2. Environmental and associated evidence, i.e. that present in the vicinity of the body,

3. Anamnestic evidence i.e. that based on the deceased's ordinary habits, movements, and day to day activities.

All three sources of evidence should be explored and assessed before offering an opinion on when death or a fatal injury occurred.

There are two methods for estimating the time of death

1. *The rate method:*

Measuring the change produced by a process which takes place at a known rate which was either initiated or stopped by the event under investigation, i.e. death. Examples include the amount and distribution of rigor mortis, the change in body temperature, and the degree of putrefaction of the body.

2. *The concurrence method:*

Comparing the occurrence of events which took place at known times with the time of occurrence of the event under investigation, i.e. death. For example, a wrist watch stopped by a blow during an assault, the extent of digestion of the last known meal.

Postmortem Changes and Time of Death

Many physico-chemical changes begin to take place in the body immediately or shortly after death and progress in a fairly orderly fashion until the body disintegrates. Each change has its own time factor or rate. Unfortunately, these rates of development of post mortem changes are strongly influenced by unpredictable endogenous and environmental factors. Consequently, the longer the post mortem interval, the wider is the range of estimate as to when death probably occurred. In other words, the longer the post mortem interval, the less precise is the estimate of the time of death.

1. Algor mortis (body cooling)

This is the most useful single indicator of the time of death during the first 24 hours post mortem. Some writers would regard it as the only worthwhile corporal method. It is of some importance to note that the use of body temperature estimations to assess time of death applies only to cool and temperate climates since in tropical regions there may be a minimal fall in body temperature post mortem and in some extreme climates, (e.g. central Australia) the body temperature may even raise after death. The normal oral temperature fluctuates between 35.9oC (96.7oF) and 37.2oC (99oF). In practice either the temperature is measured per rectum or the intra-hepatic/sub-hepatic temperature is measured via an abdominal stab. Oral and axillary temperatures should not be used. Since heat production ceases soon after death but loss of heat continues the body cools [3, 4].

During life the human body loses heat by radiation, convection, and evaporation. Heat loss by conduction is not an important factor during life, but after death it may be considerable if the body is lying on a cold surface. The fall in body temperature after death mainly depends upon a loss of heat through radiation and convection, but evaporation may be a significant factor if the body or clothing is wet. Newton's law of cooling states that the rate of cooling of a body is determined by the difference between the temperature of the body and that of its environment. Consequently, a plot of temperature against time gives a curve which is exponential. However, Newton's law applies to small inorganic bodies and does not accurately describe cooling of the human body which has a large mass, irregular shape, and is composed of tissues of different physical properties. Practical observations indicate that the cooling of a human body is best represented by a sigmoid curve when temperature is plotted against time. Thus, there is an initial maintenance of body temperature which may last for some hours - the so-called "temperature plateau" - followed by a relatively linear rate of cooling which subsequently slows rapidly as the body approaches the environmental temperature [5].

Thus the two important unknowns in assessing time of death from body temperature are:

(1) The actual body temperature at the time of death; and (2) The actual length of the post mortem temperature plateau.

The linear rate of post mortem cooling is affected by environmental factors and cadaveric factors other than the environmental temperature and the body temperature at the time of death. These include:

1. The "size" of the body The greater the surface area of the body relative to its mass, the more rapid will be its cooling. Consequently, the heavier the physique and the greater the obesity of the body, the slower will be the heat loss [6, 7].

2. Clothing and coverings. These insulate the body from the environment and therefore cooling is slower [8].

3. Movement and humidity of the air. Air movement accelerates cooling by promoting convection and even the slightest sustained air movement is significant. Cooling is said to be more rapid in a humid rather than dry atmosphere because moist air is a better conductor of heat.

4. Immersion in water. A cadaver cools more rapidly in water than in air because water is a far better conductor of heat [9].

2. Rigor mortis

Ordinarily, death is followed immediately by total muscular relaxation – primary muscular flaccidity - succeeded in turn by generalized muscular stiffening – rigor mortis. After a variable period of time rigor mortis passes off spontaneously to be followed by secondary muscular flaccidity. The first investigation of rigor mortis is attributed to Nysten in 1811 [5].

No measurable shortening of muscle occurs during rigor mortis unless the muscles are subjected to tension. When rigor is fully developed, the joints of the body become fixed, and the state of flexion or extension of these joints depends upon the position of the trunk and limbs at the time of death. If the body is supine then the large joints of the limbs become slightly flexed during the development of rigor. The joints of the fingers and toes are often markedly flexed due to the shortening of the muscles of the forearms and legs.

The view that the development of rigor mortis could produce significant movements of the body was promoted by Sommer, in about 1833, and the postulated movements became known as "Sommer's movements"[5].

Rigor mortis results from a physico-chemical change in muscle protein, the precise nature of which is unknown. When the muscle tissue becomes anoxic and all oxygen dependent processes cease to function, then the level of ATP is maintained by anaerobic glycolysis which results in increasing levels of pyruvic and lactic acids. Eventually, the muscle glycogen is depleted, the cellular pH falls to around 6, and the level of ATP falls below a critical level beyond which rigor rapidly develops. Normally ATP inhibits the activation of the linkages between actin and myosin; a fall in the level of ATP allows the irreversible development of these linkages. In individuals who have been exhausted or starved before death, the glycogen stores in muscle are low, so that rigor may develop rapidly. Some authors have simplified the concept of the development of rigor mortis by taking the view that a fall in the muscle pH to around 6.6 - 6.3 results in coagulation of the actinomyosin [10].

Classically, rigor is said to develop sequentially, but this is by no means constant, symmetrical or regular. Ante-mortem exertion usually causes rigor to develop first in the muscles used in the activity. Typically, rigor is first apparent in the small muscles of the eyelids, lower jaw and neck, followed by the limbs, involving first the small distal joints of the hands and feet and then the larger proximal joints of the elbows, knees and the shoulders and hips. Shapiro [10]

As a general rule when the onset of rigor is rapid, then its duration is relatively short. The two main factors which influence the onset and duration of rigor are (a) the environmental temperature and (b) the degree of muscular activity before death. Onset of rigor is accelerated and its duration shortened when the environmental temperature is high. In addition to these two principal factors, other endogenous and environmental factors are claimed to influence the onset of rigor. Onset is relatively more rapid in children and the aged than in muscular young adults. It develops early and passes quickly in deaths from septicaemia or from wasting diseases.

In temperate climates rigor will typically start to disappear at about 36-48 hours after death. However, if the environmental temperature is high then the development of putrefaction may completely displace rigor within 9-12 hours of death [11]. Accelerated putrefaction resulting from ante-mortem septicaemia may also lead to a rapid displacement of rigor.

3. Adipocere

Saponification or adipocere formation is a modification of putrefaction characterized by the transformation of fatty tissues into a yellowish-white, greasy, (but friable when dry), wax-like substance, with a sweetish rancid odor. Mant states that when its formation is complete it has a sweetish smell, but during the early stages of its production a penetrating ammoniacal odour is emitted and the smell is very persistent [12]. It floats on water, and dissolves in hot alcohol and ether. When heated it melts and then burns with a yellow flame. Ordinarily it will remain unchanged for years. Adipocere develops as the result of hydrolysis of fat with the release of fatty acids which, being acidic, and then inhibits putrefactive bacteria. Adipocere develops first in the subcutaneous tissues, most commonly involving the cheeks.

Under ideal warm, damp conditions, adipocere may be apparent to the naked eye after 3-4 weeks [10]. Ordinarily, adipocere formation requires some months and extensive adipocere is usually not seen before 5 or 6 months after death.

Conclusion

Forensic dentistry plays a major role in the identification of those individuals who cannot be identified visually or by other means. The unique nature of, our oral anatomy ensure accuracy when the techniques used for post-mortem identification are correctly employed.

The sociologist Ruth Richardson summed up post-mortem decomposition aptly: "The physicality of a human corpse is undeniable. The dead body is predisposed to decay". This decay that the human body undergoes acts as a valuable aid in post mortem identification of the person. Whatever method is used to calculate the estimated time since death from body temperature, all the variable factors must be taken into account.

Web links

1. www.google.com
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