Forensic Science International 289 (2018) 124–129

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Algorithm for establishing the time of death of a dog based on temperature measurements in selected sites of the body during the early post-mortem period

P. Listos[a,*], M. Gryzinska[b], J. Batkowska[b], M. Grela[a], A. Jakubczak[b]

[a] Department and Clinic of Animal Internal Diseases, Sub-Department of Pathomorphology and Forensic Medicine, Faculty of Veterinary Medicine, University of Life Sciences, Gleboka 30, 20-612 Lublin, Poland

[b] Institute of Biological Basis of Animal Production, Faculty of Biology, Animal Sciences and Bioeconomy, University of Life Sciences, Akademicka 13, 20-950 Lublin, Poland

ARTICLE INFO

Article history:
Received 30 October 2017
Received in revised form 24 March 2018
Accepted 2 May 2018
Available online 26 May 2018

Keywords:
Body temperature
Dogs
Forensic veterinary medicine
Multiple regression
Time since death

ABSTRACT

Post-mortem measurements were made of the body temperature of dogs. The aim of the study was to evaluate and verify a reliable mathematical model that can be used to establish the time elapsed since the death of a dog during the initial post-mortem period at room temperature, using the eye (vitreous body), internal organs (heart, liver, kidney and lung), and rectum as sites for temperature measurement. The measurements were performed at six points in the body using an electronic thermometer in conjunction with a temperature probe. The method of temperature measurement is simple and does not cause perceptible macroscopic changes or disfigure the carcass. Multiple regression analysis was shown to be suitable for estimating the time elapsed from death to the discovery of the body for a period up to 12 h post-mortem. The proposed multiple regression equation using body weight and the temperature at a specific site reduces manipulation of the carcass to a minimum and thus reduces error in establishing the time of death. The multiple regression model makes it possible to precisely estimate the time elapsed since the death of the animal.

1. Introduction

Determining time of death is a complex process that takes into account numerous biological and environmental factors [1–3]. Precise establishment of the time and cause of death is one of the fundamental tasks of forensic and legal medicine. Estimation of time of death makes it possible to narrow a field of suspects and verify witness testimony, and thus is crucial for discovering objective truth [4,5].

The first literature data on the use of temperature measurements to establish the time of death date back to the first half of the 19th century [6,7]. In the 1930s temperature was measured with a thermistor [8,9]. The exponential curves and temperature tables developed were only approximate. Later, attention was drawn to the deviations of the post-mortem cooling curves from a typical exponential function [10,11] as well as to the effect of water evaporation from the surface of the body. The 'size factor', i.e. the body's surface area and weight, was responsible for the rate at which it cooled. Sellier [12] introduced the concept of a cylinder of infinite length as a theoretical model of the human body, and stated that the radius of the body is the most important parameter describing temperature curves, while the type and thickness of thermal insulation are less significant. Marshall and Hoare [13] showed that in the early post-mortem period (12 h) body temperature can be described by a sigmoid curve, not an exponential curve, and at the same time proposed a double-exponential model that can be applied not only to a naked body but also to a clothed human body. The result, and thus an erroneous estimation of time of death, may be influenced by handling of the body, e.g. turning, covering or moving it [14], as well as by variations in the outside temperature [15]. The post-mortem interval can be reliably determined up to 24 h after death, or when the body temperature cools to the ambient temperature. The double-exponential model was confirmed by Brown and Marshall [16], who also showed that the use of more than two exponential terms only complicates the model.

* Corresponding author.
E-mail addresses: piotr.listos@up.lublin.pl (P. Listos), magdalena.gryzinska@up.lublin.pl (M. Gryzinska), justyna.batkowska@up.lublin.pl (J. Batkowska), malgorzata.grela.up@gmail.com (M. Grela), andrzej.jakubczak@up.lublin.pl (A. Jakubczak).

https://doi.org/10.1016/j.forsciint.2018.05.004
0379-0738/

The aim of the study was to evaluate and verify a reliable mathematical model that can be used to establish the time elapsed since the death of a dog during the initial post-mortem period at room temperature, using the eye (vitreous body), internal organs (heart, liver, kidney and lung), and rectum as sites for temperature measurement.

2. Material and methods

The study was conducted on 21 carcasses of dogs aged 7–16 years. The dogs weighed from 4.5 to 48 kg. They were divided into three weight groups: small dogs (up to 10 kg), medium dogs (10–30 kg), and large dogs (over 30 kg). Each group comprised 7 individuals. The animals were euthanized due to advanced age-related health problems or untreatable cancer. All dogs used in the study had intact skin and short hair. The dogs were euthanized with an IV overdose of sodium pentobarbital. The exact time of death was known in all cases used in the study because the dogs had been euthanized by a veterinarian. All animals were kept in the same supine position throughout the study. The dogs' owners consented to the use of the carcasses as research material.

The carcasses were stored in a room in which the temperature, humidity and air flow were continuously measured. The results were recorded every 10 min using an anemometer (Airflow TA-440A). The physical parameters of the air, which were constant over the entire study period, were as follows: temperature 18 °C, relative humidity 65% and mean air flow 0.1 m/s.

The temperature in the orbit, rectum, kidney, heart, lung and liver was measured every half hour for 12 h from the time of death. A needle probe was inserted into the orbital soft tissue in the vicinity of the medial canthus, moving along the medial rectus muscle towards the superior orbital fissure into the vitreous body to a depth of 25 mm. A measuring probe was inserted into the rectum to a depth of 4 cm. In the case of the other organs, a probe was inserted under ultrasound guidance. The temperature was recorded automatically using a separate probe placed in each of the examined sites for 12 h. No necropsy was performed on the carcasses. The first measurement of internal temperature was made at the moment the animal was euthanized. Temperature was measured with a TERMIO-25P electronic thermometer with accuracy of ±0.01 °C in conjunction with a 4 mm × 120 mm ST-02 temperature probe (Termoprodukt, Poland). Statistical analysis of the data was performed using the SAS statistics package (SAS 1996). Multiple regression analysis was performed to formulate equations for estimating time on the basis of temperature and body weight (Figs. 1 and 2).

3. Results

The varied declines in organ temperatures in dogs in different weight groups were the justification for including body weight in the mathematical model. The mean temperatures in the rectum, orbit and internal soft tissues at each time interval after the dogs were euthanized indicate a gradual decline in temperature over

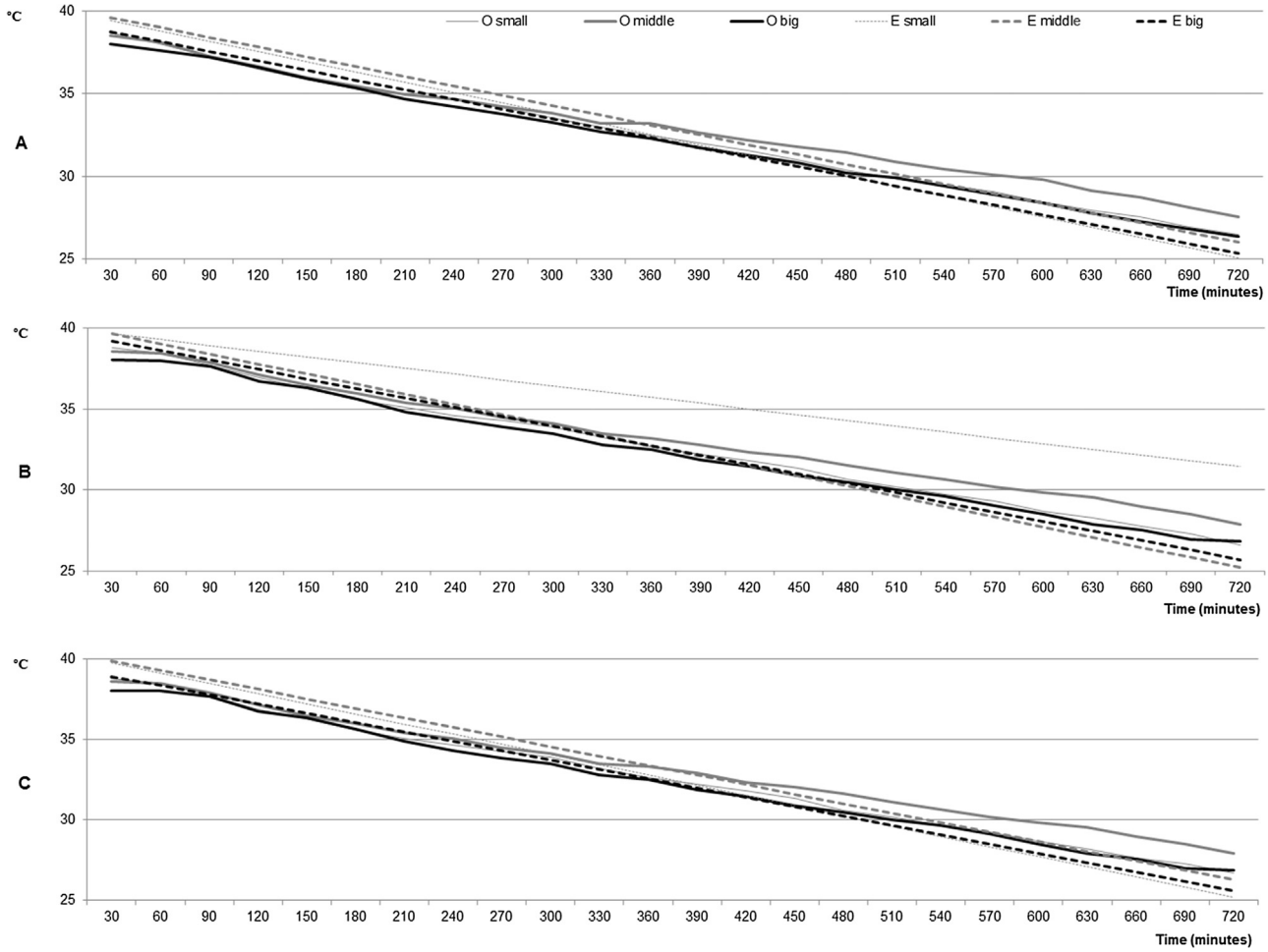

Fig. 1. Temperature measured in the (A) rectum; (B) heart; (C) lungs vs. estimated on the basis of the statistical model.