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Artificial Intelligence in Prediction of Post Mortem Interval (PMI) Through Blood Biomarkers in Forensic Examination-A Concept

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Abstract: *Determining the post mortem interval PMI or time of death is a critical step in forensic investigations. Accurate estimation of the PMI is an important task for a forensic examiner. Recent developments in biochemical technologies have started to identify biomarkers in different biological fluids such as blood, urine for PMI estimation. Researches focusing on the use of blood in PMI estimation suggest that the femoral vein blood must be collected for measuring biochemical components. Forensic investigations are hurtling toward the introduction of Artificial Intelligence AI, an intelligence exhibited by machines that are trained to learn and solve problems. The present project outlines a concept of a device that can be used in the prediction of the PMI through providing the profile of different metabolites in blood such as Lactate dehydrogenase LDH, A separate amino transferase AST, triglycerides and cholesterols. In addition to the measurement of blood pH. Use of these biochemical markers could be promising tools in forensic death investigations.*

Keywords: Post mortem interval, time of death, biological fluids, artificial intelligence, lactate dehydrogenase, a separate amino transferase, triglycerides, cholesterols, pH

I. INTRODUCTION

Artificial intelligence (AI) is actually developing in most of the fields including forensic science. People are approaching to understand the impact of AI in everybody's life through the digital science which is now easily available.

In forensic investigations, when investigators encounters a deceased, the main task is to decipher the time that has elapsed between death and discovery of the body. Time since death is defined as post mortem interval (PMI).Estimation of a time frame of death can help the investigators to reach to a conclusive state of the appropriate time of death which can further assist the courtroom proceedings in accepting or rejecting the statements of suspects and witnesses[1].

Prediction of PMI is one of the most challenging variables to quantify and establish for forensic examiners for over years despite numerous development in this area [2]. Egyptians and Greeks preformed autopsies on criminals during the early century BC. Later, all methodologies followed for PMI estimation were derived from these previous performance [3].Researches focusing on determining the time of death are divided into two main groups: the early post mortem period and the late postmor temperiod. From death until the beginning of tissue decomposition, early post mortem period is defined. Whereaslate post-mortem period is known as skeletonization or alterations of the bony matrix[4].

Several approaches have been established to define the time of death depending on short or longer PMI. Determining the time of death is more difficult with longer PMI[5]. Electrical and mechanical stimulation of skeletal muscles few hours postmortem have been used[6].Another researches consider entomology as one of the best method for determination of short as well as long PMI [7].In multiple studies, a relationship was established between decomposition of the body and PMI. Few minutes after death, many biochemical changes start in the body. These changes were divided into five phases of decomposition: fresh, bloat, active decay, advanced decay and dry remains

([8], [9]). Recent studies focus on the estimation of the PMI by biochemical markersthroughthe analysis of chemical substances released after death and accumulated in the body([10], [11]). Researchers studied these biochemical markers in PMI determination in different body tissues such as blood, brain [12], skeletal muscle [13] and pancreas [14]. Biochemical changes of blood biomarkers have been related to three elements including the agonal period of anoxia, the extension of biochemical fluctuations in the early PMI, and the repartition of diffusible constituents between red blood cells and blood serum [15]. The blood markers can be classified within two main categories: metabolites such as sodium, chloride, potassium, ammonia, urea and proteins such as lactate dehydrogenase (LDH) and Aspartate aminotransferase (AST).

Cell disruption starts with the release of water and enzymes responsible for the degradation of biomolecules such as proteins, lipids, and carbohydrates [16]. These changes progress until the body completely decomposes [17].

Several researches suggest that the blood is an ideal tissue to use for determination of time of death ([10], [18]). Researches showed that the entire quantity of protein in the blood has been measured as an indicator for PMI [19]. Among blood proteins, two enzymes help in PMI determinations: LDH, an enzyme typically restricted to the cytoplasm of cells and released out only after cell deathand AST, an enzyme converting aspartic acid to glutamate. Blood concentration of these enzymes increased in the first three days after death[20]. In addition to total amount of proteins, number of studies investigated blood glucose level in postmortem to predict time since death and showed that estimation of postmortem blood glucose does not provide any specific information [21]. This can be mainly due to the fact that the postmortem blood glucose is related to several factors decreasing or increasing its level [22]. Other studies showed a postmortem decrease in the triglyceride and cholesterol concentration in blood in vitro over time [23]. Some researchers reported changes in blood pH as examined in animal corpsespostmortem [24].

In this paper, the concept of estimating the time of death during crime investigation rely on the use of a device measuring different biomarkers in blood such as the concentration of LDH and AST considered as protein biomarkers, triglycerides and cholesterols as lipids biomarkers, as well as measuring the pH level in the blood.

II. MATERIALS AND METHODS

Dosage of LDH LDH provides a preliminary biomarker for estimating PMI. It catalyses the conversion of pyruvate to lactate and NADH to NAD^+. After death, cells release LDH into the bloodstream where its concentration increase within a few hours of postmortem. This phase is followed by a lighter increase for the next 48-72 hours, reaching its highest concentration after that phase in postmortem[25].Quantification of LDH in the blood can be realized through colorimetric method where LDH reduces NADH to NAD^+. The later absorbs a specific probe to produce a color (λmax = 340 nm).

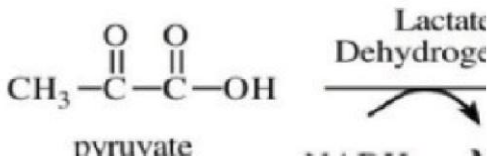

Fig. 1. Mechanism for the reaction catalyzed by LDH.

In our device concept, for the blood dosage of LDH, a measured volume of blood serum should be diluted than applied to a strip within the device. This strip comprises pyruvate and NADH. LDH activity is measured by the disappearance rate of NADH at 340 nm with reference to a calibration curve using LDH calibration. The temperature of the reaction is maintained at 37^0C and the total reaction time is in the range of few minutes (2-3 min).

Dosage of ASTAST is released into the extracellular space in postmortem cases. The augmentation of postmortemblood AST has been noticed in the first 60 hours post mortem [26].Quantification of AST in the blood can be realized through colorimetric method where glutamate is measured by the generation of a blue color product through an enzyme coupled reaction cycle(λmax= 510nm).

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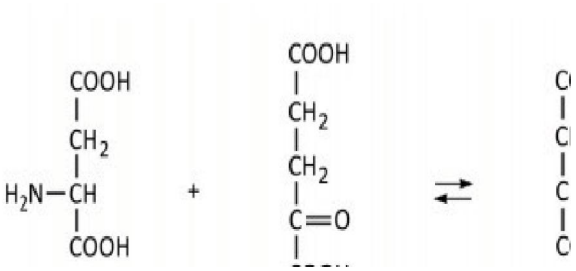

Fig. 2. Mechanism for the reaction catalyzed by AST.

For the dosage of AST in the deceased blood through the use of this device, the colorimetric method of Reitman and Frankel (1957)at 37^0C can be applied [27].

Dosage of triglyceride Quantification of total triglyceride in blood uses enzymatic hydrolysis by a lipase leading to liberation of glycerol and free fatty acids (1). A kinase then phosphorylate glycerol leading to the formation of glycerol-3phosphate (2) which in turn is oxidized by glycerol phosphate oxidase. This reaction produces hydrogen peroxide (3). Peroxidase catalyzes then the redox-coupled reaction of H_2O_2 with 4-aminoantipyrine and N-Ethyl-N-(3-sulfopropyl)-manisidine (ESPA), producing a purple color (4) (λmax= 530550nm).

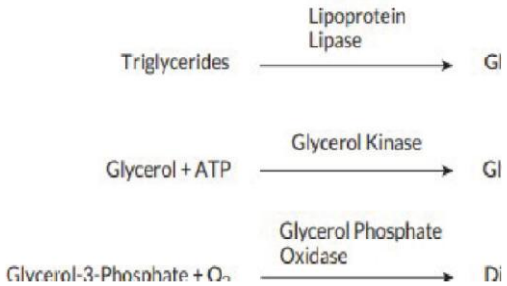

Fig. 3. Dosage of total blood triglyceride.

We propose the dosage of total serum triglycerides through direct colorimetric procedure followed by Fossati and Principe (1982) [28].

Dosage of CholesterolTotal blood cholesterol is measured using an enzymatic colorimetric method, using cholesteryl esterase to hydrolyzecholesteryl esters (1), cholesterol oxidase to produce hydrogen peroxide (2) and peroxidase plus a dye to form a coloured product (3) (λmax= 620nm).

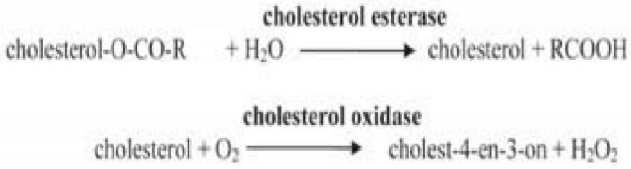

Fig. 4. Dosage of total blood Cholesterol

In our experiment, we propose the dosage of total blood cholesterol following the principle of Allain et al (1974) [29].

Determination of pH level of bloodpH of blood can be determined through colorimetric technique by which H^+ ion concentration can be determined with accuracy on single drops of fluids as described by Lloyd and Felton (1921) [30].

III. DISCUSSION

Over the last few years, broad work has focused on determining the PMI through changes in the biochemical constituents of different body fluids such as blood.

In the present study, we propose a concept of simultaneous dosage of different metabolites in blood such as LDH, AST, triglycerides, cholesterols level as well as the pH level.Normal pH blood level is controlled within the normal range of 7.35 to 7.45. Alkaline pH more than 7.45 and acidic pH less than 7 can lead to death [31]. After death, the pH of blood

changed [24]. Studies showed that, pH of blood changed from 7 to 5.5 twenty hours postmortem [32]. The accumulation of acidic metabolites especially lactic acid lower the blood pH. Postmortem level of lactate dehydrogenase (LDH) increase in blood leading to the production of lactic acid. In recent study, postmortem concentration of lactate in heart blood has proved to increase 20 times one hour after death and 70 times twenty four hours postmortem [33].

Our concept of research focuses on studying the implication of two blood enzymes (LDH and AST)mainly considered as potential biomarkers for PMI determinations. Other biochemical markers useful in postmortemdetermination include blood lipid metabolites such as triglycerides and cholesterols.

IV. CONCLUSION

When murder victim is found atcrime scene, the blood can be collected from the femoral vein.Then, blood can be analyzed directly using the proposed device with AI for the dosage of LDH, AST, triglycerides and cholesterols but not the glucose. The pH level of blood can also be measured. These data combined can be interpreted and compared to different database to estimate the PMI. The practicality of this device should be evaluated on an institutional foundation and decision made with regard to using this device.

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