Original Article

Postmortem Interval Estimation by Sturner's Equation Based Upon Vitreous Potassium Level

Postmortem Interval & Vitreous Potassium

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ABSTRACT

Objective: To determine the level of postmortem vitreous Potassiumand to correlate it withknown postmortem interval by using Sturner' equation and develop a new equation if the above mentioned equation does not work in our set up.

Study Design: Confirmatory Analytical study

Place and Duration of Study: This study was conducted at the medicolegal autopsies in the Mortuary of King Edward Medical University, Lahore and samples were analyzed in the Pathology Department of same institution from December 2012 to May 2013.

Materials and Methods: 102 samples were obtained just before the commencement of autopsy. Cases with known cause and time of death were included in the study. Head injury, unknown, putrefied and poisoning cases were not included. Sample collection took 06 months. Relevant information were collected on a detailed Proforma for each case.

Results: Linear correlation between vitreous potassium level and time since death($r=0.428$, $P<0.001$) was significant. An Ordinary Regression equation was developed which measured more accurate PMI as compared to other well-known equations and seemed to be a more appropriate model for our settings.

Conclusion: Our analysis has shown that the formula (equation number 5) developed in this research is comparatively more helpful for our setup than other well-known formulae for the estimation of PMI.

Key Words: Postmortem Interval (PMI), Vitreous Humor, Potassium**,** Ordinary Regression Equation, Inverse Regression Equation, Sturner's equation.

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INTRODUCTION

It is the duty of police officer under section 174 CrPC to investigate death under suspicious circumstances.[1] Authorized Medical officers are asked to perform medicolegal autopsy and give the opinion regarding time since death besides fatal period and cause of fatality. After death numerous chemical variations occur in different fluidsin a sequential way till the body is totally fragmented.[2,3] Vitreous potassium concentration is known to be widely used bio marker in the estimation of time since death.[2]

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Many researchers have highlighted a linear relationship between the postmortem interval and vitreous potassium level.[4]

After death, cell membrane of retinal cells convertsinto a semi permeable. Consequently, potassium starts to come out into vitreous humor steadilyup to 120-125 hours after death. This potassium leakage appears to provide a form of biological clock that provides a mean to assess time since death.[5,6] Many formulae are available to estimate the relation between the vitreous potassium and the postmortem interval[7].

Sturner conducted a study on 91 autopsies and noticed a linear rise in Vitreous potassium.On the basis of his data he proposed a formula to find out postmortem interval.[6,8]

Death Time [Hrs] = 7.14 [K^+level (mEq/L)] – 39.1

In our study Postmortem interval is calculated through the Sturner's equation by using potassium level in vitreous humor[5,8,9] and if it is not applicable in our setup then develop our own equation base upon our own demographics. Thus, the following are the objectives of this study.

Research Objectives:

1- To find out vitreous Potassium level
2- To use Sturner's equationin estimation of postmortem interval (known); and

3- To develop a new equation if the above mentioned equation does not work in our set up.

MATERIALS AND METHODS

102 vitreous Potassium samples from the mortuary of KEMU, Lahore and analyzed in Pathology Department by Auto analyzer. Sampling was started from 20th December 2012 and continued up to 15th May 2013. The postmortem interval range was from 5 hours and 30 minutes to 36 hours.[10] The causes of the death included firearm injuries, asphyxial deaths, blunt and sharp edge weapon injuries, and complication arising from myocardial diseases. All the dead bodies were grouped into four groups depending upon the time since death. So group I was with Postmortem interval of 0-12hrs, group II 12.01-24hrs, group III 24.01-36hrs and group IV more than 36hrs.

Scleralpuncture was performed for each sample just before autopsy by retracting the lid near the outer canthus of left eye. 20 gauge needle attached with 10ml syringe was used. Needle tip was kept directed toward the globe center. Procedure was carried out with care to avoid any damage to the retina.[3,11]

In most of the cases 2-3 ml of fluid was collected. Normal saline was reintroduced to restore the tension in the globe for cosmetic reasons. Clear samplesnot containing any piece of slough tissue contamination were used. Samples were kept at -20°Ctemperature before analysis.[12-15]

Inclusion Criteria: Dead bodies with known cause and time of death.

Exclusion Criteria: Putrefied dead bodies, poisoning cases, damaged eyes due to injury and unknown dead bodies were not included in the study.

RESULTS

In the present study data of 102 cases were obtained. In all these cases exact death time or postmortem interval was known. Data analysis was carried out on SPSS statistical software version 16. Mean PMI in hours was 16.35 ± 5.20 hours and range was 5.30 hrs. to 32 hrs. Meanof the potassium was 7.10 ± 2.15mEq/L and range was 1.7 to 14.7mEq/L. Correlation between potassium and PMI was significant (r=0.4280, P<0.001).Male cases were 81.37% and females 18.63% only.

Figure No.1: Obtaining vitreous humor for analysis[6]

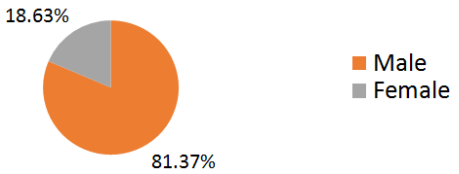

Figure No.2: Gender Distribution of the study cases

The main causes of death in studied cases were Firearm Injuries (FAI), Asphyxia (AD), Blunt Weapon Injury (BWI), Cardio vascular Diseases (CVD), and Sharp Weapon Injury (SWI).

Statistical analysis also showed that vitreous potassium level significantly is not dependent upon cause of death generally.

Total cases were divided into four groups based upon time since death. However, the range of PMI was 5.30 to 32 hours so there were only following three groups shown in Table 2. The results indicate that the vitreous potassium level increases after death with the passage of time.

A wide range of age distribution was also observed in the studied cases and range was 14 years to 70 years. It had no significant effect on vitreous potassium level. Scatter plot was used todisplay the relation between PMI and K^+ values. Estimated regression line for PMI in hours by the Direct Method (Ordinary Regression) with graph is given in equation shown here:

$$PMI\ (Y) = 1.036\ K^+\ (X) + 8.973$$

Estimated PMI (in Hours) was also calculated by the Inverse Regression Method as, the fitted line of K^+, when PMI was taken as independent variable. Estimated regression line for potassium level K^+ is given in equation given below

$$K^+\ (Y) = 4.225 + 0.1768\ PMI(X)$$

$$PMI(X) = -\ 23.90 + 5.66 \times K^+\ (Y)$$

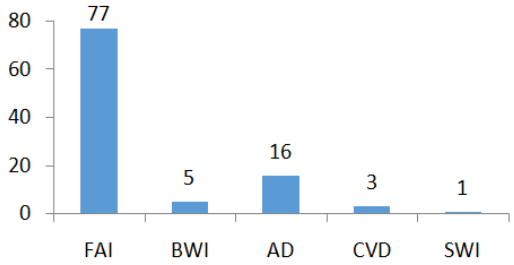

Figure No.3: Distribution of the studied cases based on the cause of death

Application of Sturner's and Regression Equations:

All the vitreous K^+ values of the samples were used to determine PMI by utilizing both Regression Equations (Ordinary and Inverse) and Sturner's Equation. The PMI in most of the cases was very wrong with inverse regression and Sturner's equations. Whereas with

ordinary regression equation not even a single calculation of PMI was in negative and the deviations between the estimated PMI and actual PMI were much less than 06 hours in more than 80% samples. The mean error of the estimated PMI for with all three equations is given in Table 3.

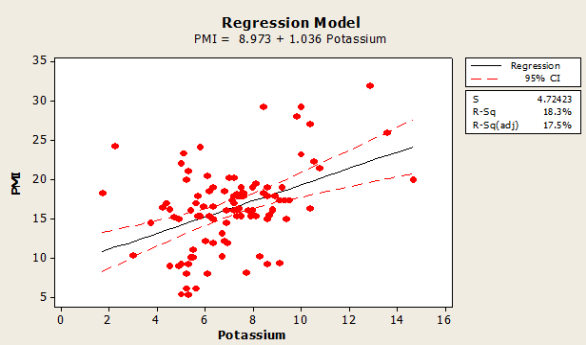

Figure No. 4: Regression Model for PMI

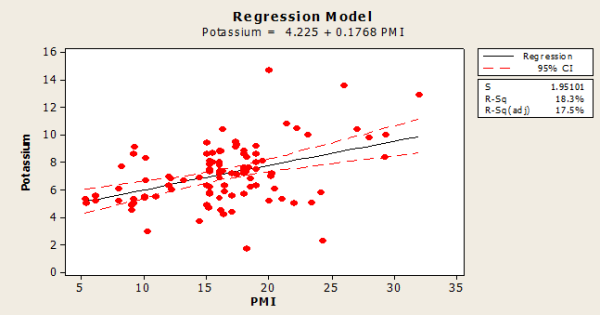

Figure No.5: Regression Model for Vitreous Potassium Level

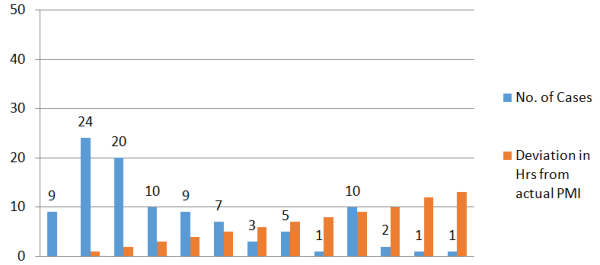

Figure No.6: Deviations (in hours) between estimated PMI and actual PMI utilizing the vitreous $K^+$by Ordinary Regression Equation

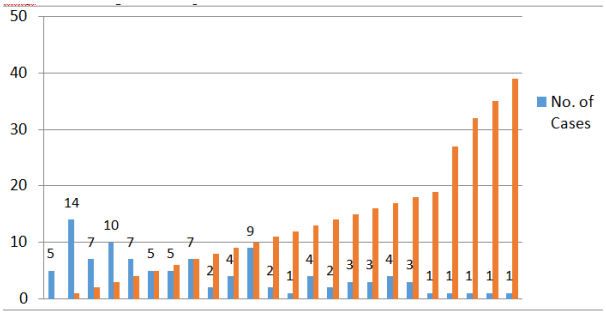

Figure No.7: Deviations (in hours) between estimated PMI and actualPMI utilizing the vitreous $K^+$by Inverse Regression Equation

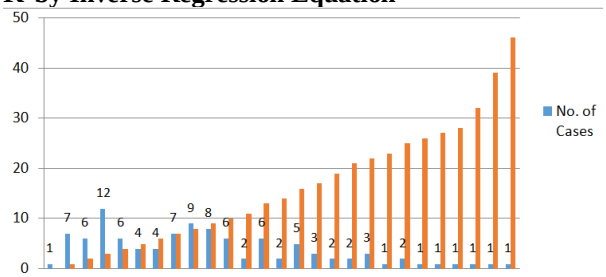

Figure No.8: Deviations (in hours) between estimated PMI and actual PMI utilizing vitreous $K^+$by equation of Sturner

Table No.1: Vitreous Potassium level in male and female cases

Distribution of Cases based on Gender				
Sex	No of Cases	Range K^+ (mEq/l)	Mean K^+ (mEq/l)	SD
Male	83	1.73 - 10.4	6.84	1.76
Female	19	2.26 - 14.7	8.27	3.16
Statistical Analysis				
Comparison	t value	p value	Significance	
Male & Female	1.902	p<0.05	Significant	

Effect of sex was significant on the levels of vitreous K^+(higher in females).

The margin of mean error with Ordinary Regression and Inverse Regression is Zero. (The regression model has the basic first assumption that mean of the error should be zero.In the Table 3, for equation of Sturner, mean of the error is not equal zero. So Ordinary Regression and Inverse Regression Model seem to be a better good equations according to this analysis.

Table No.2: Distribution of Cases based on PMI

Distribution of Cases based on PMI						
S No	TSD / PMI	No of Cases	Percentage of Cases	Range K^+ (mEq/l)	Mean K^+ (mEq/l)	SD
Group I	0-12 Hours	19	18.63%	3 - 9.1	5.89	1.54
Group II	12.1 to 24 Hours	77	75.49%	1.73 - 14.7	7.13	1.96
Group III	24.1 to 36 Hours	6	5.88%	8.4 - 13.6	10.85	1.99
Statistical Analysis						
Comparison		**t value**	**p value**	**Significance**		
Group I & Group II		2.958	P<0.005	HS		
Group I & Group III		5.6	P<0.005	HS		
Group II & Group III		4.421	P<0.005	HS		

Table No.3: Descriptive Statistics of Errors

Descriptive Statistics of Errors		
	No. of Cases	**Mean**
Error due to Ordinary Regression	102	.0025
Error due to Inverse Regression	102	.0215
Error due to Sturner equation	102	4.6492

Ordinary Regression, Inverse Regression and Sturner's Equation were used to estimate the PMI by utilizing vitreous K^+values.

In case of Ordinary Regression Equation, 82% cases had06 hours deviations from real PMI (Figure 6). VitreousK^+rise was fairly consistent in early hours of postmortem interval but scatter range increased after 20 hours. Moreover with this equation not even a single case of estimated PMI was in negative.

The inverse regression equation use with all the samples showed deviations of -14 to 40 hours from the actual PMI. These deviations were quite erratic and depicting no relation with the actual PMI. The estimated PMI was negative for four cases (as it can't be so).

With equation of Sturner estimated PMI was in negative for twenty two cases (as it cannot be). In most of the cases either overestimation or underestimation of PMI showed no comparison with real PMI. Rangeof deviations was -27 to 53 hours from the real PMI.

DISCUSSION

During criminal investigation of death, the authorized medical officer (working in the ministry of health) conducting autopsy has to find out the cause and manner of death and probable estimate of the postmortem interval. Postmortem vitreous humor is stable fluid as it is inert, isolated and protected from sudden biochemical changes taking place in the body and process of putrefaction after death.

Postmortemvitreous potassium showed a fairly linear increase with the passage of time. Potassium rise was consistent during the early hours and scatter range increased after 20 hours. Samepattern of PMI vitreous potassium rise is seen in various studies.[8,12,14-20]

Significant effect of gender variation was observed on the levels of potassium. Male cases showed the mean vitreous potassium level of 6.84 mmol/l; whereas, the female cases showed the mean vitreous potassium level of 8.27 mmol/l - slightly higher vitreous potassium levels were observed in the female cases.

The data analysis of the female cases revealed that the cause of death in more than 60% cases was asphyxia. The analysis results showed that the vitreous potassium level is fairly higher in asphyxial death cases (7.63 mmol/l). Our study included 19 female samples.

The slopes of line of linear regression for PMI and postmortem vitreous potassium rise in literature varies and range is 0.14 mmol/L per hour[19] to 0.332 mmol/l per hour.[20] The zero hour intercept vary from 4.2 to 8.0 mmol/l is reported.[21]In the present study, the rise of regression slope line is 0.1768 mmol/l per hour and it is in close agreement to the slope line of 0.17 mmol/l per hour which was obtained in a combined original data for vitreous potassium of six studies.[4,22-26] It is believed that the regression line slope should be relatively steeper. Relatively flat slopes have tendency to give higher readings for postmortem interval.

The mean error of Ordinary Regression and Inverse Regression was almost Zero thus fulfilling the first basic assumption for regression model, E (e) = 0). It was not zero for Sturner's equation. Therefore, Ordinary Regression equation appeared to be a more appropriate model for our demographics.

CONCLUSION

Postmortemvitreous humor biochemistry is significant. Postmortemvitreous K^+ levelhas important role in determination of PMI. Thus, it can solve the major problem faced by the authorized medical officer conducting autopsy to precisely estimate the postmortem interval of the deceased, assist the Police investigation and the courts of law in finalizing the just verdict.

This study showed that the Ordinary Regression Equation is relatively more helpful for our setup than other well-known formulae for the estimation of PMI.

Author's Contribution:

Concept & Design of Study:	Nasreen Akhtar
Drafting:	Nasreen Akhtar, Riasat Ali
Data Analysis:	Nasreen Akhtar
Revisiting Critically:	Wardah Anwar, Anam Iqbal
Final Approval of version:	Nasreen Akhtar, Arif Rashid Malik

Conflict of Interest: The study has no conflict of interest to declare by any author.

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