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Original Article

Study of Potassium in Synovial Fluid as an Aid in Determining the Time Since Death

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ABSTRACT

The estimation of the postmortem interval is one of the fundamental questions to be addressed at an autopsy examination. Accurate estimation of postmortem interval can be crucial to the successful investigation of a suspicious death. Knowing the postmortem interval can has investigators eliminate suspects if they have a valid alibi for when death occurred, allowing investigators to focus on other lands. Numerous studies have examined the potential utility of body fluids in estimating time of death. The purpose of this study was to establish correlation between postmortem interval and synovial potassium concentration and to derive a formula for determination of postmortem interval within reasonable time limit by putting synovial potassium concentration. Therefore in 50 cases with known time of death, synovial fluid was taken and analysed for potassium level on Beckman coulter autoanalyzer. Result shows linear rise of potassium consideration with increasing postmortem interval.

Keywords: Postmortem interval, Synovial fluid, Potassium, Time since death

INTRODUCTION

Postmortem interval is the time between the death and postmortem examination of a dead body. This is important in knowing when the crime was committed. Accurate determination of time since death is one of the most vital and yet one of the most difficult problems in medical field [1]. Postmortem interval can be calculated from taking into consideration many factors like physical changes after death such as rigor mortis, postmortem staining, body temperature, greenish discolouration of right iliac fossa, changes in eyes, contents of stomach and bladder and modified form of decomposition like adipocere and mummification [2].

No doubt, by these methods postmortem interval can be measured in a scientific manner, but none of the parameters are either singly or collectively reliable in measuring exact postmortem interval because of environmental factors [3]. Hence forensic experts and biochemists have been concentrating on biochemical changes that occur in body fluids such as blood and compartmental fluids like vitreous humour, synovial fluid, cerebrospinal fluid, pleural fluid and pericardial fluid. Amongst these the most widely used method is the estimation of postmortem concentration in vitreous humour [4].

But vitreous is useless when dealing with eye trauma, ocular disorders, when head or eyes are missing, in mutilated bodies etc. Measurements of biochemical levels in synovial fluid have some advantages over those of blood and cerebrospinal fluid. The most obvious is easy sampling. Similar to the vitreous humour, synovial fluid is isolated and well protected anatomically by the cells lining the synovial membrane and is usually well preserved at postmortem, less subjected to contamination and putrefactive changes and biochemical changes occur slowly as compared to blood or cerebrospinal fluid. Only few studies of medico-legal interest on synovial fluid have been published. Potassium is the most commonly used component in postmortem biochemistry. Intracellular concentration of potassium is as high as 2-40 times the concentration of potassium within plasma. After death, there is a depletion of ATP, hence the ATP-dependent pumps begin to fail. So the concentration gradient of sodium and potassium which is maintained by the Sodium-Potassium ATPase pump by the active transport of the electrolyte against the concentration gradient is lost. Autolysis is the aseptic enzymatic breakdown of body tissues. After the breakdown of cell membrane, the selective permeability that maintains the concentration difference inside and outside the cell is lost. So there will be diffusion of electrolytes along its concentration gradient. The normal potassium value is 3.5-5.3mmol/L. Potassium concentration in synovial fluid is approximate that of the serum as synovial fluid is an ultrafiltrate of plasma.

MATERIAL AND METHOD

This study was carried out in department of Biochemistry in association with department of Forensic Medicine and Toxicology, Jhalawar Medical College, Jhalawar. This study was done on 50 cases with known time of death who was brought in the mortuary of department of Forensic Medicine and Toxicology for autopsy. The information regarding time of death were collected from hospital records. These cases were studied between the period from December 2018 to April 2019.

The exclusion criteria were:-

- All the Cases Where the Time of That Was Unknown.
- Body in Advanced Stage of Decomposition.
- Body Kept in Cold Storage.
- The Extracted Sample Is Cloudy, Turbid or Hemorrhagic in Nature.
- Cases of Joint Disease/deformity (osteoarthritis, Rheumatoid Arthritis etc).
- Cases of Knee Joint Injury.

Synovial fluid extraction can be done from knee, shoulder, elbow, wrist, ankle, foot but sufficient amount of fluid can be easily extracted from knee joint so this joint is selected for extraction in present study.

To obtain synovial fluid, 18 gauge aspiration needle is inserted just superior to the upper pole and lateral to the lateral border of the Patella at the level of Patello-femoral joint. The aspiration needle is directed horizontally and at the right angle to the long axis of the limb [5].

Synovial fluid samples were obtained from left and right knee joint separately at the same time. The synovial fluid sample should be examined immediately or within a few hours after arthrocentesis [6]. So the sample were immediately sent to Biochemistry lab for analysis. Samples were analysed on BECKMAN COULTER AUTOANALYZER. If immediate analysis was not possible then the samples were stored at 4 degree centigrade for analysis on the very next working day.

OBSERVATION

Out of total 50 cases examined, 36 cases (72%) were males and 14 cases (28%) were females. In this study maximum number of cases were in the age group of 20 to 40 years and maximum number of cases fall in range of 12 to 24 hours of time since death.

Majority of cases were from poisoning-23 (46%) followed by trauma-22 (44%), natural death-4 (8%) and burn-1 (2%) respectively. Age distribution varied from 13 to 70 yrs and potassium concentration varied from 3.90 to 14.70meq/l. Maximum postmortem interval was 2.3hrs and minimum was 62.38hrs.

According to Table 1, there is statistically significant positive correlation between postmortem interval and

Table 1: Correlation Between Time Since Death (hrs) and Potassium Levels

	Mean	Std. Deviation	N	r value	P value
Time Since death (hrs)	9.1192	9.35234	50		
Potassium Right	6.6700	2.31298	50	0.869	<0.0001*
Time Since death (hrs)	9.1192	9.35234	50		
Potassium left	6.6520	2.29420	50	0.857	<0.0001*
Time Since death (hrs)	9.1192	9.35234	50		
Potassium	6.6610	2.30302	50	0.863	<0.0001*

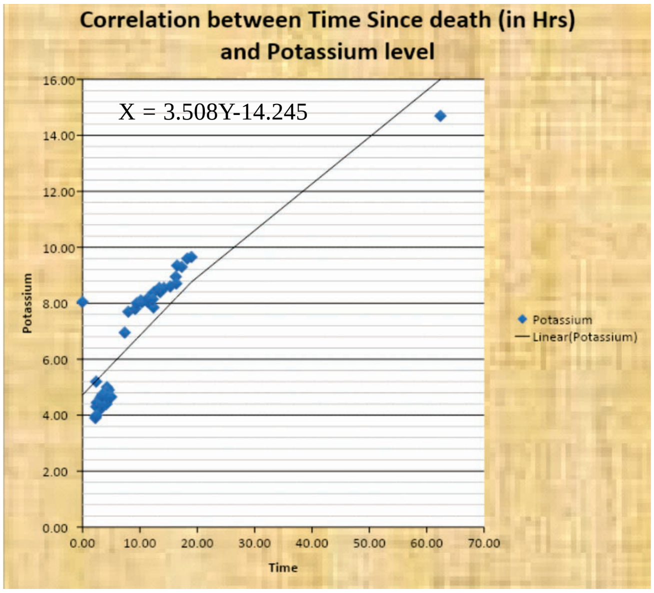

Figure 1: Regression line of Time Since death (X) with Potassium (Y)

potassium level (p <0.05). According to correlation if time interval increases, potassium concentration also increases. As seen from the scatter diagram it is observed that some linear relationship exists between potassium and time since death.

Table 2 indicates that there is no statistically significant difference in the potassium values in right and left knee joint. The P value is >0.05.

As per Table 3 no significant correlation was found between age and potassium concentration. Regression coefficient between age and potassium concentration is 1.811.

Table 4 shows no significant difference in potassium level in male and female cases.

Table 5 indicates that there is significant difference in potassium level among causes of death. According to

Table 2: Comparison of Left and Right Knee Values of Potassium

	Mean	N	Std. Deviation	T value	P value
Potassium Right	6.6700	50	2.31298	1.219	0.229
Potassium Left	6.6520	50	2.29420		

Table 3: Correlation Between Age and Potassium Levels

	Mean	Std. Deviation	N	r value	P value
Age	33.9400	16.46940	50		
Potassium Right	6.6700	2.31298	50	0.245	0.086
Age	33.9400	16.46940	50		
Potassium Left	6.6520	2.29420	50	0.260	0.069
Age	33.9400	16.46940	50		
Potassium	6.6610	2.30302	50	0.253	0.077

Table 4: Distribution of Potassium According to Gender

	Gender	N	Mean	Std. Deviation	T value	P value
Potassium Right	Female	14	6.6357	2.00906	0.065	0.949
	Male	36	6.6833	2.44745		
Potassium Left	Female	14	6.6429	2.02777	0.017	0.986
	Male	36	6.6556	2.41690		
Potassium	Female	14	6.6393	2.01773	0.041	0.967
	Male	36	6.6694	2.43167		

Table 5: Distribution of Potassium According to Cause of Death

Cause of death		Potassium Right	Potassium Left	Potassium
Burn	Mean	4.2000	4.2000	4.2000
	N	1	1	1
	Std. Deviation	—	—	—
Natural	Mean	9.9250	9.8500	9.8875
	N	4	4	4
	Std. Deviation	3.34701	3.14166	3.24381
Poisoning	Mean	5.9261	5.9174	5.9217
	N	23	23	23
	Std. Deviation	1.91316	1.92818	1.91992
Trauma	Mean	6.9682	6.9500	6.9591
	N	22	22	22
	Std. Deviation	2.01007	2.01441	2.01197
	F Value	4.868	4.779	4.827
	P value	0.005*	0.006*	0.005*

mean potassium level is higher in natural death and lower in burn death.

1. Regression line of Time Since death (X) with Potassium (Y) in natural death
   X = 7.628Y-50.074
2. Regression line of Time Since death (X) with Potassium (Y) in death due to poisoning
   X = 2.299Y-5.984
3. Regression line of Time Since death (X) with Potassium (Y) in trauma death
   X = 2.559Y-8.290

According to Table 6, there is statistically significant positive correlation between postmortem interval and potassium level ($p < 0.05$). There was only one case of burn in our study, so no correlation could be made out.

DISCUSSION

One of the commonest requirements of postmortem examination is the determination of postmortem interval. Synovial fluid is a well investigated fluid compartment in rheumatology [7] and handbooks of joint fluid analysis are available [8]. However, only a few studies of medico-legal interest on synovial fluid have been published, dealing with alcohol concentration [9], drug distribution into synovial fluid and postmortem chemistry regarding the cause of death [10]. As synovial fluid is more protected and less prone to burns or atmospheric variations in comparison to other body fluids such as cerebrospinal

Table 6: Correlation Between Time Since Death (hrs) and Potassium Level in Various Causes of Death

Cause of death	Variables	Mean ± ISD	R Value	P Value
Natural	Time since death	25.37 ± 24.79	0.997	0.003
	Potassium	9.89 ± 3.24		
Poisoning	Time since death	6.17 ±5.00	0.833	0.0001
	Potassium	5.92 ±1.91		
Trauma	Time since death	9.52 ± 5.33	0.965	0.0001
	Potassium	6.96 ± 2.01		

fluid and blood. It was thought that the postmortem chemistry of synovial fluid might be helpful in estimating postmortem interval with much desired accuracy.

In this study it was observed that there is considerable rise in the synovial potassium level with increasing postmortem interval (Statistically significant positive correlation). The rise of synovial potassium ion concentration varied from 3.90 to 14.70 meq/l.

This observation is supported by many other workers including Madea *et al.*[11]; Sahoo *et al*.[12]; Sheikh[13]; Siddhamsetty *et al.*[14] and Surender *et al.*[15]. However, correlation coefficient and regression equation in each study was different. Singh *et al.*[16] revealed a significant correlation between time since death and sodium/ potassium ratio. Arikeri *et al.* [17] in his study observed rise in potassium concentration with time interval but the result was statistically insignificant. Tumram *et al.*[13] observed a weak correlation between synovial potassium and death interval in first 12 hrs which became significant stronger after that. This may be due to the biphasic nature of potassium concentration which rise more rapidly in the first few hours after death. Sahoo *et al.*[12] reported that there exists a significant positive correlation of potassium concentration in relation to death interval but somewhat erratic rise of potassium concentration while Sheikh [3] showed a steady rise of potassium concentration up to a maximum 48 hours of death and had a positive correlation with time lapse.

The postmortem changes in biochemical electrolytes particularly potassium occur with postmortem breakdown of metabolite mainly due to anaerobic glycolysis due to which active membrane transport stops and loss of selective membrane permeability and diffusion of ions and other parameters according to their concentration gradient starts. Rise of potassium in the synovial fluid can be attributed probably to autolysis of the cell membrane of the synovium. The synovial compartment having a homogenous distribution of cations like potassium throughout showed a stronger correlation coefficient with time since death[19].

Tumram *et al.*[18] worked on comparative study of various biochemical parameters in synovial fluid and vitreous humour for determination of death interval and found that synovial fluid potassium values can be more confirmatory. Madea *et al.*[11] also did a comparative study of various parameters in synovial fluid and vitreous humour for determination of death interval and concluded same result that synovial fluid can be used as a postmortem examination tool but analysis of synovial fluid is somewhat more complicated because of their higher viscosity compared to vitreous humour.

In addition, Kelly *et al.*[20] addressed that cations are homogeneously distributed throughout the synovial compartment, thus making collection less problematic compared with vitreous humour.

Yielding *et al.*[21] found potassium values in normal and diseased joints to be quite variable. More *et al.*[10] found that biochemical electrolyte modifications were related more directly to duration of the pathological process that leads to death then with the natural process.

This study results are not consistent with the study of Yahia *et al.*[22]. In their study they found that potassium concentration decreased for 8 hours in synovial fluid of donkey.

On the basis of SPSS (version 20.0) software we have derived followings:-

Coefficient of correlation:- We found positive correlation between synovial potassium concentration and postmortem interval. The coefficient of correlation for potassium ion concentration in the synovial fluid is 0.863. This indicates that there is high degree of correlation between potassium concentration and postmortem interval.

Coefficient of regression:- The value of coefficient of regression was 3.508 meq/l/hr.

Regression equation:- X = 3.508Y-14.245

Where X = Time since death in hrs
Y = concentration of potassium in synovial fluid

Different studies showing formula for determination of death interval from cadaveric synovial potassium concentration.

Madea Death Interval = $(6.2475 \times K^+) - 45.9375$

Sahoo Death Interval = $(0.1136 \times K^+) + 2.94$

Sheikh Death Interval = $(2.20 \times K^+) + 5.28$

Tumram Death Interval = $(2.8319 \times K^+) - 15.4164$

Siddhamsetty Death Interval = $(4.751 \times K^+) - 27.920$

This study shows that there is no statistically significant difference in the levels of synovial potassium concentration between the two knee joints of body. Our findings are consistent with result of Srettabunjong *et al.*[23]. They observed no statistically significant difference in biochemical constituents in between two knee joints and both eyes as well. This finding suggests that either side of the knee can be solely used for forensic application.

In the present study we found significant difference between synovial potassium level and various causes of death. Sheikh[2]; Singh *et al.* [16] and Surender *et al.* [15] did not find any relation between synovial potassium concentration and causes of death.

We observed that age and sex factor has no appreciable role in the change in level of potassium concentration in synovial fluid after death. This result was supported by work of [2, 15, 16, 18, 23].

SUMMARY AND CONCLUSION

We have observed linear rise of potassium ion concentration in synovial fluid with increasing postmortem interval. There is significant difference between synovial potassium concentration and various causes of death. No significant difference exist for synovial potassium concentration in the same pair of knee joint at the identical postmortem interval. Factors like age and sex do not influence the synovial potassium values.

Presently the postmortem synovial biochemistry for the estimation of postmortem interval has been limited use because of different conclusions reached by different workers and the lack of uniformity in their equations. So this topic needs further research to bring into use. However synovial fluid can be used as an alternative postmortem sample for certain biochemical measurements for forensic application and further research. Instead of being over-reliable on a single test, we suggest that, the results of multiple biochemical tests should be considered in conjunction for accuracy.

REFERENCES

[1] Reddy KN, Murty OP. The Essentials of Forensic Medicine and Toxicology. New Delhi: Jaypee Brothers Medical Publishers; 2014.

[2] Sheikh NA. Study of Sodium and Glucose levels in Cadaveric Synovial Fluid to estimate Post-Mortem Interval. Indian Journal of Forensic Medicine and Pathology. 2008; 1(3): 55.

[3] Sheikh NA. Estimation of Postmortem Interval According to Time Course of Potassium Ion Activity in Cadaveric Synovial Fluid. Indian Journal of Forensic Medicine & Toxicology. 2007; 1(2): 45–9.

[4] Coe JI. Vitreous Potassium as a Measure of the Postmortem Interval: An Historical Review and Critical Evaluation. Forensic Science International. 1989; 42(3): 201–13.

[5] Pandey S and Pandey AK. Intra Articular and Allied Injection. 2nd edition; New Delhi Jaypee publication; 2005.

[6] McCarty DJ. Synovial fluid. In: Koopman WJ, Arthritis and Allied Conditions. a Textbook of Rheumatology. 13th edn. Baltimore: William and Wilkins;1996.

[7] Kushner I, Somerville JA. Permeability of Human Synovial Membrane to Plasma Proteins. Relationship to Molecular Size and Inflammation. Arthritis & Rheumatism: Official Journal of the American College of Rheumatology. 1971; 14(5): 560–70.

[8] Gatter RA. A Practical Handbook of Joint Fluid Analysis. Lea and Febinger, Philadelphia; 1984.

[9] Ohshima T, Kondo T, Sato Y, Takayasu T. Postmortem Alcohol Analysis of the Synovial Fluid and Its Availability in Medico-legal Practices. Forensic Science International. 1997; 90(1-2): 131–8.

[10] More DS, Arroyo MC. Biochemical Changes in the Synovial Liquid in Corpses with Regard to the Cause of Death. calcium, Inorganic Phosphorus, Glucose, Cholesterol, Urea, Nitrogen, Uric Acid, Proteins and Albumin. Journal of Forensic Science. 1985; 30 (2): 541–546.

[11] Madea B. Is There Recent Progress in the Estimation of the Post-mortem Interval by Means of Thanatochemistry? Forensic Science of International. 2005; 16(2-3):139–49.

[12] Sahoo PC *et al*. Study of Sodium, Potassium and Glucose Level in Synovial Fluid for Estimation of Time Since Death. Journal of Forensic Medicine and Toxicology. 2005; 15(1): 14–16.

[13] Tumram NK, Ambade VN, Dangre AP. Thanatochemistry: Study of Synovial Fluid Potassium. Alexandria Journal of Medicine. 2014; 50(1): 369–372.

[14] Siddhamsetty AK, Verma SK, Kohli A, Verma A, Puri D, Singh A. Exploring Time of Death from Potassium, Sodium, Chloride, Glucose & Calcium Analysis of Postmortem Synovial Fluid in Semi Arid Climate. Journal of Forensic and Legal Medicine. 2014; 28(1): 11–4.

[15] Surender SS. An Overview- on Biochemical Methods Used for Estimation of Time Since Death. International Journal of Information and Computer Science. 2018; 5(9): 55.

[16] Singh D, Sharma SK, Prasad R, Bansal YS. Determination of Time Since Death from Biochemical Changes in Human Synovial Fluid: S–curve Model. International Journal of Medical Toxicology & Legal Medicine. 2007; 9(2): 6–11.

[17] Arikeri SM, Laveesh MR, Priyadarshini AV, Suna P, Farzana UK, Michael N, Raveendram N – Determination of Time Since Death by Estimating Sodium and Potassium Levels in Synovial Fluid. International Journal of Research in Pharmaceutical and Biomedical. 2007; 4(4): 194–196.

[18] Tumram NK, Bardale RV, Dongre AP. Postmortem Analysis of Synovial Fluid and Vitreous Humour for Determination of Death Interval: A Comparative Study. Forensic Science International. 2011; 204(1): 186–190.

[19] Orten JM, Neuhaus OW. Composition of Synovial Fluid. Human Biochemistry. 1982; 1(1): 588–9.

[20] Kelly WN, Harris E, Ruddy S, Sledge CS**.** Synovial Fluid Analysis. Textbook of Rheumatology. 3rd edition WB Saunders company; 1981.

[21] Yielding KL, Platt D, Holley HL. Synovial fluid. I. Comparison of Sodium and Potassium Concentrations in Normal and Diseased Joint Fluid. Proceedings of the Society for Experimental Biology and Medicine. 1954; 85(4): 665–7.

[22] Yahia D, Abd El-Hakiem MAH. Biochemical analysis of synovial fluid, cerebrospinal fluid and vitreous humour at early postmortem intervals in donkey. Journal of Advanced Veterinary Research. 2014; 4(4); 6–11.

[23] Srettabunjong S, Thongphap W, Chittamma A. Comparative and Correlation Studies of Biochemical Substances in Vitreous Humor and Synovial Fluid. Journal of Forensic Sciences. 2019; 64(3):778–85.

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