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Original Research Article

Study of Cerebrospinal Fluid Electrolyte Concentration in Medico-Legal Cases

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Key words
Cerebrospinal fluid,
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Abstract

Introduction: Post-mortem changes in the cerebrospinal fluid occur rapidly and are quite erratic. And among the electrolyte's potassium and sodium ion concentration gives a more precise value of time since death. The ratio of sodium and potassium ions is a better parameter for predicting time since death compared to postmortem interval estimation from sodium or potassium values alone. Hence, we studied the correlation between CSF potassium and sodium ion changes with time since death. **Material and Methods:** The present study was carried out in the department of forensic medicine of a tertiary care government hospital from June 2018 to December 2021. This study has been extended to directly compare the accuracy of determining death intervals from biochemical parameters of cerebrospinal fluid. In 124 medico-legal cases with a known time of death, cerebrospinal fluid was taken from ventricles and analysed for sodium and potassium. **Results:** A strong correlation between time since death and the ratio of sodium to potassium is observed. The time since death was regressed by the ratio of sodium to potassium. **Conclusion:** The changes in electrolytes (sodium, potassium) in CSF after death do not show any significant relation with the age, sex, various causes of death of the individual. The TSD and value of CSF potassium and sodium level show particular relationship in estimating time since death.

1. Introduction

While investigating a crime, it is essential for the investigating officer to have adequate knowledge about the place of death, cause of death, "Time since death" (TSD) etc. In criminal cases, the Post-Mortem Interval (PMI) serves as an important clue for the investigating officer to probe and helps them eliminate the innocent.[1] The importance of PMI is to aid in the identification of an accused, and in cases of violent death, it limits the number of suspects and helps to validate or

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reject an alibi and verify witnesses' statements. In civil cases also, the time of death plays a vital role in deciding about the legal heirship, inheritance, or succession of the property. To fix time since death based on Post-mortem changes alone has been a constant challenge to medico-legal workers in many situations. The time of death becomes very important in certain situations. And this question is raised to the most of Forensic experts by the Investigating Police Officers, which is answered sometimes with touch of accuracy. Though it is not possible to fix the exact time of death by autopsy finding alone, yet some close and reasonable approximation should always be aimed at.[1,2] Many biochemical changes begin to take place in the body immediately or shortly after death and progress in fairly orderly way until the body disintegrates. These changes occur in various body fluids[3, 4] including vitreous humour of eye and CSF.[5,6,7,8]

The present study was undertaken to investigate whether post-mortem analysis of CSF electrolytes is useful for the estimation of PMI and, if yes, what parameters are better correlated with PMI.

2. Material and Method:

The present study was carried out in the department of forensic medicine of a tertiary care government hospital from June 2018 to December 2021. Prior permission from the Institutional Ethics Committee of the college was obtained. The ethics committee approval number is: EC/PG/372/OCT/2018 date: 19/10/2018. The material for study is cerebrospinal fluid (C.S.F). Those cases with a known time of death and PMI of less than 24 hours were enrolled in the study. During the study period, all medico-legal autopsy cases and all the information about the deceased like name, age, sex, date and time of death, date and time of collection of C.S.F, cause of death, mode of death, temperature, and sodium and potassium concentrations, were fully recorded in specially designed proforma. A total 124 cases were included in the study during the stipulated study period.

Inclusion criteria:

1. Time of death should be known.
2. Sample collection within 24 hours of death.
3. Cases having clear C.S.F. were taken.

Exclusion criteria:

1. Any case of head injury, brain pathology, bleeding diathesis, vertebral column and spinal cord injury.
2. More than 24 hours of time of death
3. Cases of burns
4. Cases of extensive soft tissues injuries
5. Age <15 years and >80 years
6. All those cases where the time of death was unknown
7. The cases in which the extracted sample is turbid/ cloudy/yellow.

Methods of Collection of CSF:

The cranial cavity was opened and the vault will be removed to expose the dura and brain. Dura is gently cut from the vault region of the brain; both cerebral hemispheres are separated apart from the midline by left hand to expose the corpus callosum; a 10ml plastic disposable syringe with a wide bore cannula (18 gauge) is inserted on the posterior and dependant parts of corpus callosum for 1.5cm depth; the needle is directed posterior downwards and slightly laterally in each hemisphere and cerebrospinal fluid is withdrawn.[9]

The samples were taken immediately to the central laboratory, department of biochemistry for analysis. The collected samples were immediately centrifuged at a rate of 3000 rpm for a period of 3 minutes. The supernatant solution was collected in a sterile tube and analysed for sodium and potassium ions by using the ion-selective electrode method.

The individual analysis findings were entered in the master chart, and analysis was done. The statistical analyses for the data were carried out using the software statistical package for social sciences (SPSS 15). The analyses were done first on the control group with a known time of death and the correlation between C.S.F, sodium and potassium and PMI. A formula for PMI based on sodium and potassium levels was established.

3. Observations and Results:

In the present study, 124 cases are within the stipulated study period. In the present study out of 124 cases, the minimum and maximum values of the post-mortem interval noted were 2.35 hours and 22.00 hours respectively. The post-mortem interval is taken from the time of death declaration in hospital records. The post-mortem interval (PMI) was divided into four groups as shown in the **Table no. 1**.

The sample collections were divided into four groups as per the PMI/ time since death (TSD). 26.61% of cases belonged to 0 -6 hours of TSD, 56.45% of cases belonged to 6 to 12 hours, 13.71% of cases belonged to 12 -18 hours and 3.23% of cases belonged to 18 -24 hours.

Table 1: Showing the distribution of cases as per Postmortem interval (PMI).

Groups	PMI (Hours)	No. of Cases	%
1	0 to 6	33	26.61
2	6 to 12	70	56.45
3	12 to 18	17	13.71
4	18 to24	4	3.23
Total		124	100

Table 2: Summary statistics.

Parameters	Min	Max	Mean	SD
Potassium	21	48	30.28	5.29
Sodium	96	147	114.99	14.982
Time since death	2.55	22	8.38	3.78

Table 3: Comparison between TSD, potassium and sodium

Time since death (hours)	Potassium		Sodium	
	Mean	SD	Mean	SD
0-6	27.16	4.07	122.50	11.077
6-12	30.60	4.08	114.56	10.30
12-18	35.38	7.09	104.62	8.64
18-24	36.38	7.34	108.80	8.79
P- value	<0.001		<0.001	

The minimum (Min) potassium of the dead body is 21q/L, and the maximum (Max) potassium is 48q/L, with an average potassium was 30.28 q/L and standard deviation (SD) of 5.29q/L. The minimum sodium of the dead body is 96q/L and the maximum sodium is 147q/L with an average sodium was 114.99 q/L and standard deviation of 14.982q/L **(Table 2)**. The potassium and sodium levels were compared with the time since death. The potassium level was increasing with the increase in time since death. At the sixth-hour postmortem interval after death, it ranges from 21-38meq/L with a mean 27.16meq/L, SD of 4.07 meq/L. At the twelfth hour postmortem interval after death, it ranges from 23.20-40meq/L with a mean 30.60 meq/L, of SD 4.08meq/L. At the eighteenth-hour postmortem interval after death, it ranges from 26-48.10 meq/L with a mean 35.38 meq/L, of SD 7.09 meq/L. At the 24-hour postmortem interval after death it ranges from 27-47meq/L with a mean of 36.38 meq /L, of SD 7.34meq/L. The sodium level was decreasing with the increase of time since death. At the sixth hour postmortem interval after death, it ranges from 97-147meq/L with a mean 122.50meq/L, of SD 11.08meq/L. At twelfth hour postmortem interval after death, it ranges from 100-145meq/L with a mean 114.56meq/L, of SD 10.30meq/L. At eighteenth hour postmortem interval after death, it ranges from 98-122meq/L with a mean 104.62meq/L, of SD 8.64meq/L. At 24th hour postmortem interval after death it ranges from 96-120meq/L with a mean 108.80meq/L, of SD 8.79meq/L **(Table 3)**.

Regression: The strong correlation between time since death, potassium and sodium is observed. The time since death was regressed on potassium and sodium levels **(Graph no. 1)**.

Graph no. 1: Relation between potassium, sodium and TSD.

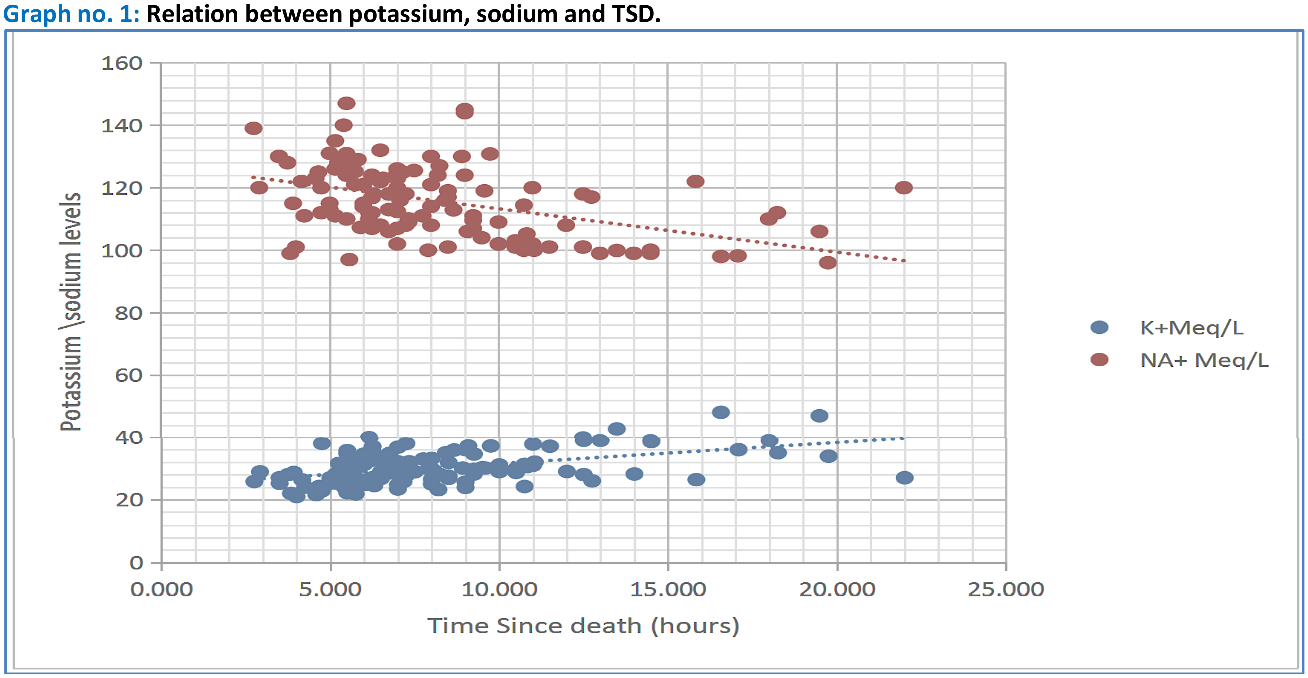

Table 4: Model Summary with Dependent variable: Time since death, Independent variables: Potassium and Sodium.

Model	R	R square	Adjusted R Square	Std. Error of the Estimate (SEE)
1	0.571	0.327	0.315	3.09760
2	0.527a	0.278	0.272	3.19417

a. Predictors: (Constant), ratio

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate (SEE)
2	0.527a	0.278	0.272	3.19417

Table 5: Coefficients

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	17.329	1.359		12.747	0.000
Ratio	-2.305	0.336	-0.527	-6.854	0.000

a. Dependent Variable: TSD.

Table..

The impact of potassium and sodium was significant on TSD in hours, with a beta value of 0.266, p-value <0.001 and beta value -0.104, p-value <0.001 respectively **(Table no. 4 & 5).**

Regression of TSD with Na/K:

A strong correlation between time since death and the ratio of sodium to potassium is observed. The time since death was regressed by the ratio of sodium to potassium. The regression equation can be written as,

TSD *= 17.329-2.305 × (Sodium/Potassium)*

The linear formulae to estimate PMI were derived by the following equation: y = axe + b, where y is electrolyte concentration, x is PMI in hours (dependent variable), a is the slope, and b is the intercept of the regression line.

The regression equation can be written as,

TSD = 12.245+ 0.266 × Potassium - 0.104 × sodium

As such, we have tried to document the correlation between potassium and sodium ion concentrations in CSF and time since death at this centre. There is a significant correlation between changes in levels of both ions and time since death.

4. Discussion:

The hospital-based prospective study was conducted on cases coming for medico-legal autopsy at the Department of Forensic Medicine and Toxicology. Post-mortem biochemistry is an important but seldom-practiced tool in death investigations. Mason, Klyne & Lennox (1951), Naumann H. N. (1958), B.V.Subramanyam et al observe the post-mortem rise of CSF potassium. Their observations are consistent with our findings.[10,11,12] V. Rama conducted a study on 100 samples of CSF and observed an increase in the level of potassium ions in CSF with time since death, except during 12 to 18 hours of time since death. His observations are inconsistent with our findings.[13] Yadav J et al. revealed a significant correlation between sodium and potassium ions in CSF up to 25 hours of time of death, with an average per hour rise of 1.21 meq/h for potassium and a fall of 1.115 meq/l for sodium ions. A useful relationship between sodium and potassium ion ratios and postmortem intervals was also elicited. These observations are inconsistent with our findings.[03,14,15]

Sanjay Choudhary et al. conducted a study of potassium levels in CSF and observed that there is a consistent increase in potassium levels with time since death. These observations are inconsistent with our findings.[16] Bardale R.V. et al. (2004) observed that potassium increases with increasing post-mortem intervals and that the rise is linear.[17] The sodium in the CSF decreases with increasing post-mortem intervals, and the decrease is not linear.[18] These observations are inconsistent with our findings. Chintalwar et al. estimated the time since death from potassium ion concentration levels in CSF, CSF was aspirated from lateral ventricles after opening the skull and dura, and concentration of potassium ion was estimated over dimension expand plus auto-analyzer. In their study they found the potassium concentration r*0.944(p<0.001), the least square regression equation derived is found to be y*1.705x+18.83, where y= potassium ion concentration (in-dependant variable) and x=time since death (dependant variable). Post-mortem changes of CSF electrolyte are based mainly on the hypoxic damage of the choroid plexus. Potassium ion concentration is useful to estimate time since death;

the amount of potassium increases at a constant rate in relation to the temperature of the body during the first 20 hours. The concentration of sodium, calcium, and magnesium has no obvious relationship to time since death.[19] In our study, the time since death and the value of CSF sodium level show a particular relationship in estimating the time since death.

Bhanwar L. J., O.P. Saini et al. (2019) study 100 medico-legal autopsies to estimate time since death irrespective of age and cause of death in RTA, poisoning, hanging, drowning, and burn cases, except the head injury, vertebral column, and spinal cord injury cases, and in cases where the time of death was known. A significant inverse fair correlation existed between the time since death and K^+ level (r=0.82, p<0.001).[20] these observations are consistent with our findings. Soon after death, the volume of CSF averages 150 cc in amount, but it gradually disappears within 24-48 hours. Potassium moves into the cerebrospinal fluid progressively[21], and the rate of this diffusion is greater between the eighth and twenty-four hours after death.

Kumari Mamta et al conducted a study on 81 cases, and concluded that the time since death can be estimated by using changes in the biochemical markers in CSF. The potassium showed moderate correlation with time since death, and sodium showed weak correlation with time since death.[22] Kumari Mamta et al. conducted a study on 81 cases and concluded that the potassium showed a moderate correlation with time since death, and the sodium showed a weak correlation with time since death.[22]

The present study revealed a postmortem increase in potassium and a decrease in sodium ion concentration similar to that reported by earlier researchers in various body fluids, including CSF. The ratio of sodium and potassium ions is a better parameter for predicting time since death compared to PMI estimation from sodium or potassium values alone. Hence, we have tried to establish the correlation between CSF potassium and sodium ion changes with time since death.

5. Conclusions:

These are the conclusion from my study:

a. The changes in electrolytes (sodium, potassium) in CSF after death do not show any significant relation with the age of the individual.
b. The changes in electrolytes (sodium, potassium) in CSF after death do not show any significant relation with the sex (male, female) of the individual.
c. The changes in electrolytes (sodium, potassium) in CSF after death do not show any significant relation with the various causes of death.
d. The TSD and value of CSF potassium level show particular relationship in estimating time since death.
e. The TSD and value of CSF sodium level show particular relationship in estimating time since death.

Ethical Clearance: IEC approval is taken from the Institutional Ethical committee.

Contributor ship of Author: All authors equally contributed.

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References:

1. Adjutantis G, Coutselinis A. Estimation of the time of death by potassium levels in the vitreous humour. Forensic Sci. 1972 ;1(1):55-60.
2. Shrestha R, Kanchan T, Krishan K. Methods of Estimation of Time Since Death. [Cited 2022 Nov 20]. In: Stat Pearls [Internet]. Treasure Island (FL): Stat Pearls Publishing; 2019. Available from: https://www.ncbi.nlm.nih.gov/books/NBK549867
3. Coe JI. Postmortem chemistry of blood, cerebrospinal fluid and vitreous humor. Forensic pathology, a handbook for pathologists. US Gov. Print. Off., Washington, DC. 1977: 21-49.
4. Henry JB, Smith FA. Estimation of the postmortem interval by chemical means. Am J Forensic Med Pathol. 1980 ;1(4):341-8.
5. Coe JI. Postmortem chemistries on human vitreous humor. Am J Clin Pathol.1969;51(6):741-50.
6. Coe JI. Use of chemical determinations on vitreous humor in forensic pathology. J Forensic Sci. 1972; 17(4):541-6.
7. Kärkelä JT. Critical evaluation of postmortem changes in human autopsy cisternal fluid. Enzymes, electrolytes, acid-base balance, glucose and glycolysis, free amino acids and ammonia. Correlation to total brain ischemia. J Forensic Sci. 1993 ;38(3):603-16.
8. Deokar RB, Shendarkar AT, Patil SS. Estimation of time since death by means of changes in the eye – Vitreous humour calcium levels. Int J Healthcare Biomed Res. 2013; 1(3): 141-6.
9. Ludwig J. Handbook of autopsy practice. 3rd edition. Rochester, Minnesota: Springer Science & Business Media; 2002.
10. Mason JK, Klyne W, Lennox B. Potassium levels in the

cerebrospinal fluid after death. J Clin Pathol.1951; 4(2): 231.
11. Naumann HN. Cerebrospinal fluid electrolytes after death. Proceedings of the Society for Experimental Biology and Medicine. 1958; 98(1):16-8.
12. Donaldson AE, Lamont IL. Estimation of post-mortem interval using biochemical markers. Aust J Forensic Sci. 2014; 46(1):8-26.
13. Rama V. Assessing time since death by using changes in electrolytes in CSF and vitreous humour in bodies subjected to autopsy (Doctoral dissertation, Tirunelveli Medical College, Tirunelveli).2018.
14. Yadav J, Deshpande A, Arora A, Athawal BK, Dubey BP. Estimation of time since death from CSF electrolyte concentration in Bhopal region of central India. Leg Med. 2007 ;9(6):309-13.
15. Querido D. Double logarithmic, linear relationship between plasma sodium/potassium concentration ratio and postmortem interval during the 6–96-h postmortem period in rats. Forensic Sci Int. 1990 ;44(2-3):125-34.
16. Choudhary S. Estimation of Post-mortem Interval from the changes in Vitreous and CSF. Thesis submitted in Rajasthan University; 2001-2004.
17. Paulson GW, Stickney D. Cerebrospinal fluid after death. Stereotact Funct Neurosurg. 1971;33(3):149-62.
18. Dongre AP, Bardale RV. Estimation of time since death from cerebrospinal fluid chemistry. J Forensic Med Toxicol. 2004;21(2):37-40.
19. Chintalwar RS, Dhawane SG, Dixit PG. Estimation of Time Since Death from CSF Electrolyte. Prof. RK Sharma. 2016;10(2):2105.
20. Jakhar BL, Saini OP, Saini PK et al. Estimation of time since death by potassium ion (k+) level in cerebrospinal fluid- A postmortem study. Int J Med Sci Innovative Research. 2019; 4(2):66-72.
21. Fraschini F, Müller E, Zanoboni A. Post-mortem increase of potassium in human cerebrospinal fluid. Nature. 1963; 198:1208.
22. Kumari M, Kumar R, Chawla H, Kumari S. Estimation of time since death by biochemical markers in cerebrospinal fluid-An autopsy-based study. J Forensic Med Toxicol 2023;40(1):63-6.