

Assessment of Time Since Death using Forensic Autopsies based on the Presence of Rigor Mortis– A Cross-Sectional Study

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ABSTRACT

Introduction: Time since death is an important topic that plays major role in forensic medicine. The accurate determination of time since death is found to be helpful in medico legal investigation. Advancements in the methods for estimating time since death have enabled us to determine post-mortem interval more precisely. Since the 1850s, scientists have been working on different methods to determine post-mortem interval. Hence, the aim of the present study was to assess the time since death using method of rigor mortis in the autopsies done at the mortuary of Osmania General Hospital.

Materials and Methods: About 500 medico-legal autopsies were selected where the exact time of death was known and the body had been kept at prevailing room temperature. A good quality digital hygrometer was used to note the daily readings of temperature and humidity. Presence or absence of rigor mortis and its extent was noticed in both voluntary and involuntary muscles.

Results: More unnatural deaths are in suspicious circumstances are occurring in males when compared to females. The average duration for onset of rigor mortis was 8 hours and 39 minutes. The minimum duration in which rigor mortis had begun to appear in the body was 1 hour and 35 minutes while the longest maximum by which rigor mortis had not completely appeared in the body was 24 hours.

Conclusion: Rigor mortis has been used for assessment of time since death from long time. It is considered to be the most important and interesting method to estimate the time since death.

Keywords: Rigor Mortis, Forensic Medicine, Autopsy, Death

INTRODUCTION

Estimation of time since death is an integral part of medico-legal investigations. Post-mortem Interval is defined as 'amount of time that has elapsed since the death of the decedent'. The key goal of estimating time since death at the scene of crime is to have a preliminary idea of the time of assault and for narrowing the field of suspects.¹ Rigor mortis is a physio-chemical change that causes stiffening of the body after death. There are several reports of the use of rigor mortis for estimating time since death. Death is immediately followed by total muscular relaxation termed as 'Primary Muscular Flaccidity' which is followed by muscular stiffening – 'rigor mortis'. After a period of time (36 hours) rigor mortis gradually fades off and is followed by 'Secondary Muscular Flaccidity'.²

The primary reason for the development of rigor mortis is the loss of adenosine triphosphate from the anoxic tissue. Rigor mortis starts to develop 2-4 hours after death and

develops fully by 6 to 12 hours and gradually dissipates until approximately 72 hours after death. It has been found that post-mortem muscle proteolysis is responsible for the relaxation following rigor mortis.³ Classically, rigor is said to develop sequentially beginning from eyelids, jaw and neck followed by the limbs. The joints of the body become fixed when the rigor is fully developed, and the state of flexion of these joints depends upon the position of the trunk and limbs at the time of death. If the body is in the supine position then the large joints of the limbs become slightly flexed during the development of rigor. The joints of the fingers and toes are often markedly flexed due to the shortening of the muscles of the forearm and legs.⁴

Rigor mortis is a post-mortem change which leads to stiffening of the body muscles because of chemical changes in the myofibrils. It helps in estimating the time since death as well to recognize if the body was moved after death. The position of the body plays a major role in the establishment of rigor mortis as it is indicative of the position of the body at the time of death, unless the position is disturbed by external forces or putrefaction. At the scene of death, the body posture sometimes, needs correct forensic interpretations.⁵

It was stated that rigor mortis is known of all signs of the death and is found to be the most deceiving sign of the triad. It seems to be a common occurrence in the bodies of the extremely obese, and it takes place very rarely in the senile, lean and bony body. It is increased by heat and is decreased by cold. Rigor mortis was differentiated from the stiffness due to cold and found that both are chemically different.⁶ Reduced temperature retards the onset and prolongs the duration of rigor mortis. It is better appreciated by touch than by seeing the photographs and is measured manually by attempting to flex or extend each joint during autopsy. Rigor mortis follows primary relaxation of the muscles; it is easily possible to change the position of body parts during this period, after which the position remains stable till the

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How to cite this article: M. Sugatha, Venkata Ramana. Assessment of time since death using forensic autopsies based on the presence of rigor mortis– a cross-sectional study. International Journal of Contemporary Medical Research 2019;6(4):D11-D14.

DOI: <http://dx.doi.org/10.21276/ijcmr.2019.6.4.52>

rigor mortis disappears.⁷

During the stage of rigor mortis, if the position of the dead body is unusual with flexion at some major joints, it will remain rigid in the same position. If the rigor mortis is the well-established stage, the flexed limbs continue to stay flexed and will defy gravity, even when the support beneath them is missing. Unusual position in which the limbs are stiff and defy gravity could be due to putrefaction as well.⁸

To a forensic pathologist, fixing up of time since death is an important duty from "Investigational view point", especially when foul play is suspected. The autopsy surgeon should do his best to arrive at a closest possible deduction as to the time elapsed since death. The courts are now depending more and more on scientific evidence for establishing the proof of crime.⁹

The problem of unknown bodies, because of ever increasing floating population, it is important for the forensic experts to establish the time of death as accurately as possible to aid the investigation. Even elaborate biochemical investigations failed to yield reliable results. Search of more reliable methods continued but none is yet capable of giving the degree of accuracy that is claimed.¹⁰ Hence, the aim of the present study was to assess the time since death using method of rigor mortis in patients admitted to the hospital.

MATERIALS AND METHODS

The present study was a cross-sectional study in which 500 medico-legal autopsies done at Osmania General Hospital mortuary were selected where the exact time of death was known and the body had been kept at prevailing room temperature. To observe the effect of atmospheric and seasonal conditions, the period of study was divided into four groups corresponding to the four seasons.

A good quality digital hygrometer was used to note the daily readings of temperature and humidity. Presence or absence of rigor mortis and its extent was noticed in both voluntary and involuntary muscles. In the joints, appearance and disappearance of rigor mortis was noted by seeing their movements for resistance offered.

Effect of temperature and humidity

In the months of April to June, fully developed rigor mortis lasted from 11 hours 25 minutes to 28 hours 25 minutes while in the quarter of July to September; complete rigor mortis lasted from 17 hours 15 minutes to 34 hours 20 minutes. The maximum temperature during these months ranged from 26.6°C to 46.5°C while minimum temperature ranged between 12°C to 27.6°C. Relative humidity levels in these months varied from 95% to 31%. In the months of October to December, fully developed rigor mortis lasted from 16 hours 25 minutes to 61 hours 5 minutes while from January to March it lasted from 19 hours 5 minutes to 50 hours 15 minutes. The maximum temperature during these months ranged from 13.6°C to 35.4°C while minimum temperature ranged between 2.6°C to 20°C and the relative humidity varied from 97% to 65%.

Time of appearance and disappearance

In the present study, it was observed that the average duration for onset of rigor mortis was 8 hours and 39 minutes. The minimum duration in which rigor mortis had begun to appear in the body was 1 hour and 35 minutes while the longest maximum by which rigor mortis had not completely appeared in the body was 24 hours. The average duration for fully developed rigor mortis was 18 hours and 19 minutes, the shortest duration being 3 hours and 15 minutes and the longest 33 hours and 40 minutes.

The average duration for disappearing rigor mortis was 34 hours and 36 minutes. The shortest duration by which rigor mortis had disappeared had 15 hours and 30 minutes while one case was observed in which rigor mortis was presenting some parts of body at 70 hours and 35 minutes. In 94.6% cases rigor mortis was found to appear first in the eyelids followed by lower jaw, neck, upper limbs, trunk, lower limbs and lastly fingers and toes. It disappeared in the same fashion. However, in 5.4% cases sequence was found to be erratic.

Site of recovery

In cases, recovered from open environment, the average duration of onset of rigor mortis was early (6 hours 56 minutes) and average duration of disappearance was also early (24 hours 44 minutes) as compared to dead bodies recovered from closed environment.

Nourishment

In the present study, it was observed that in well-nourished and muscular individuals, the average duration of appearance of rigor mortis was early (6 hours 16 minutes) and it lasted for a short time (15 hours 45 minutes) as compared to moderately and poorly nourished cases in which onset of rigor mortis was late and it stayed for a longer period.

Clothing

The average duration of onset of rigor mortis (6 hours 50 minutes) and disappearance of rigor mortis (27 hours 17 minutes) was earlier in naked dead bodies as compared to clothed victims. It was observed that in cases with history of muscular activity just prior to death the average duration of onset (8 hours 5 minutes) was late while the average duration for disappearance of rigor mortis (23 hours 33 minutes) was earlier as against those cases in which the muscles were at rest.

RESULTS

In the present study, Table no. 1 shows that the majority of deaths occurred in 21 to 50 year olds, again pointing to an active life which is definitely for pursuits of livelihood. It shows clearly that there is an early amount of rigor mortis in open environment with a little variation in different gaps. In comparison, the onset of rigor has significantly increased in closed environment.

In the current study, 78.4% cases were males and 21.6% cases were females. About 56.2% victims belonged to rural area as compared to 43.6% urbanites while residence of 0.2% males was unknown. Alleged cause of death in 42.6% cases was road traffic accidents, 11.6% deaths were due to

Age	Frequency	Percentage
10-20years	61	12.2%
21-50years	324	64.8%
51-60years	85	17%
>60years	30	6%
Total	500	100%

Table-1: shows age wise distribution of study subjects

Illness	Frequency	Percentage
Present	43	8.6%
Absent	457	91.4%
Total	500	100%

Table-2: Shows the illness among the study subjects

	Open			Closed		
	Onset	Complete	Disappearance	Onset	Complete	Disappearance
10-20 years	6.12	19.0	25.22	7.32	18.22	33.16
21-50 years	5.59	18.36	27.58	7.02	17.35	34.23
>60 years	8.15	19.26	28.35	9.20	18.08	32.18

Table-3: Shows the site of recovery in relation to age in hours and minutes

S. No.	Average duration	Temperature fall	Normal rectal temp	Time
1	Onset	34 c	39.5 c	8 hrs 23 mins
2	Complete	30 c	39.5 c	19 hrs 26 mins
3	Disappearance	26 c	39.5 c	24 hrs 22 mins

Table-4: hows the average duration, temperature fall and time among the study subjects

Month	Time
April to June	11.25 to 28.25
July to September	17.15 to 34.20
October to December	16.25 to 61.5
January to March	19.5 to 50.15

Table-5: Shows the seasonal effect on rigor mortis among the study subjects

poisoning, 9.2% victims had died due to natural disease, 9% due to burns, railway accidents formed 6.8% of the share and miscellaneous other causes contributed 20.8%. 66.2% cases were observed in 21-50 years of age group in which rigor mortis lasted longer as compared to 0-20 years (12%) and above 50 years (17.8%) age (Table no. 2 and 3).

It was found that the onset of rigor was earlier in summer and delayed in winter, which with average being in the monsoon season. It was observed but not with reasonable accuracy that increased body temperature would help relative early development of rigor mortis. The reason for lack of accuracy being a very low percentage i.e., less than 1% of cases which showed a definite rise in temperature at the time of death (Table no. 4 and 5).

DISCUSSION

In the present study out of 500 cases, 78.4% cases were males and 21.6% cases were females. About 56.2% victims belonged to rural area as compared to 43.6% urbanites while residence of 0.2% males was unknown. Alleged cause of death in 42.6% cases was road traffic accidents, 11.6% deaths were due to poisoning, 9.2% victims had died due to natural

disease, 9% due to burns, railway accidents formed 6.8% of the share and miscellaneous other causes contributed 20.8%. Approximately 66.2% cases were observed in 21-50 years of age group in which rigor mortis lasted longer as compared to 0-20 years (12%) and above 50 years (17.8%) age.

It shows that more unnatural deaths are in suspicious circumstances are occurring in males when compared to females. When subjects were studied according to the location a majority subjects i.e., 56.2% of deaths were from urban areas where as 43.6% of deaths were from rural areas. The maximum no of deaths when analysed in relation to cause of the death were from RTA's followed by poisoning 11.6%, burns 9%, natural 9%, railway accidents 8% and 20% were undetermined. This indicated the extent of road safety in the country.

The study of individual subjects in the study group of 500 cases showed that 38.6% of people were well built and another 28.2% were moderately built and 33.2% were poorly built. The rigor mortis would have developed better and stayed longer in well-built and moderately built individuals whereas in the poorly built group there was delay in development and weak establishment.

A majority of cases i.e., 95.6% of cases were found to be adequately clothed as the true of their death. A small group of 4.4% was found unclothed. The unclothed victims were found after certain amount of time delay which results in loss of rigor mortis. Hence, the exact relationship between clothing and development of rigor mortis could not be established.

The association of muscular activity and its impact on the onset, development, persistence and disappearance was also recorded. Unfortunately, though not many victims showed increased muscular activity prior to their death.

About 7.6% victims possessed some amount of muscular activity. In these cases, also the victims were not always witnesses during the course of their suffering. Wherever muscular activity was tuned such cases showed early development and early loss of rigor mortis. The important aid in the study of rigor mortis was found in relation to seasons. In this study, it was clearly observed that the onset of rigor was early in summer and delayed in winter with average being in the monsoon season.

In a study done by Deepak et al it was stated by the author that the onset and duration of rigor mortis is governed by various factors. In Indian conditions it is different, compared to the temperate countries, when time since death needs to be estimated. Rigor mortis starts within 2-3 hours and takes about 12 hours to develop, persists for another 12 h, and takes about 12 h to pass off.¹¹

Rigor mortis can persist if the cycle of rigor is broken and a significant rigidity can reappear if the breaking occurs before the process is complete. There are many factors such as exercise, cause of death, temperature and nourishment which affects the onset or progression of rigor mortis into the complete body. In the present case, where the rigor mortis is seen well established all over the body, after considering the usual possibilities, the dead body must have reached the place of disposal, from 2 to 6 h after the death (scene of occurrence).

In the hot weather from April to September, the average duration of onset was 8 hours 8 minute, complete rigor mortis lasted for an average duration of 18 hours 2 minute and average duration for disappearance of rigor mortis during these months was 30 hours. In the winter months of October to March, the average duration of onset of rigor mortis was 7 hours 25 minutes fully developed rigor mortis lasted for 19 hours and 15 minutes and it disappeared at an average duration of 36 hours and 8 minutes.

The usually taught standard rule of twelve does not hold true in every case as the process of rigor mortis is influenced by many variables especially temperature and humidity which has been optimal observed in the present study. Various studies has been performed on laboratory animals by various workers all over the world but a more systematic and detailed study is required on human subjects beginning right from the time of death till the time of disposal.¹²

CONCLUSION

The ever-increasing crime rate is demanding fast and sensitive methods for determining time since death. A significant amount of work has been done by researchers to correctly determine time since death. Algor mortis, rigor mortis, supravital reactions, and post-mortem decomposition have been a routine tool for the estimation of post-mortem interval for many years. The results of conventional methods are not precise and accurate. In a country like India with wide

variations of weather, post mortem interval each and every state needs to have its own time table of rigor mortis so that it proves to be an effective tool for measuring postmortem interval.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 22-03-2019; **Accepted:** 14-04-2019; **Published:** 05-05-2019