Original Research Article

Significance of Middle ear Haemorrhagein Cases of Drowning Deaths: An Autopsy Study of Rural Punjab

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Abstract

The diagnosis of death by drowning remains a difficult task for forensic experts at the time of postmortem examination. The presence of putrefaction and postmortem artefacts cover essential signs of drowning found on external and internal examination of dead body. This study involved gross examination of middle ear cavity for presence of haemorrhage to establish a diagnosis of antemortem drowning. It was planned considering the lack of research on this subject in the North Indian population. This study was conducted in the Department of Forensic Medicine and Toxicology, Guru Gobind Singh Medical College and Hospital, Faridkot, Punjab and included drowning deaths brought for autopsy. This study helped assessing the reliability of incidence of middle ear hemorrhage to affirm the diagnosis of antemortem drowning in the absence of other external and internal signs suggestive of drowning.

Keywords: Drowning, Autopsy, Middle ear, Haemorrhage, Asphyxia

Introduction

Death is not an event, but a process[1]. Death is said to occur when there is complete and irreversible stoppage of circulation, respiration and brain stem functions.

All types of asphyxia, whether mechanical, environmental, pathological, traumatic, or iatrogenic, involve a physical barrier preventing air entry into the lungs. Due to this violent interference, these deaths are termed violent asphyxial deaths[2]. Drowning is a form of asphyxia caused by aspiration of fluid into air passages caused by complete or partial submersion in water or other fluid[1].

Classical signs of asphyxia are petechial hemorrhages of the conjunctivae, viscera and/or skin, cerebral and/or pulmonary edema, cyanosis, visceral congestion and the fluidity of the blood[3]. These have been used in the diagnosis of asphyxial death for many years but are however not always visible in every individual because of the different ways violent asphyxia deaths present, which

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include drowning, hanging, ligature, and manual strangulation, smothering, traumatic asphyxia, suffocation and choking, where the leading causes are hanging and drowning [4].

Typical findings of drowning victims are wet clothes, skin and hair when recovered early. A typical fine tenacious froth from mouth and nose is observed in bodies who die of drowning and recovered before putrefaction sets in. Aquatic debris including silt, mud, sand, gravel, vegetation, algae, and shell fragments may be found on clothes, hair and body creases or orifices. Cutis anserine, or so-called "goose flesh," is observed in erector pilaie muscles of skin in bodies submersed in cold water as well as is related to be part of rigor mortis after death. Face, neck, chest, hands, lower extremities and feet are the most common areas of postmortem lividity in prone victims found in water, however the constant moving water makes it unapparent. Soddening and skin slippage observed in hands and feet ; called washerwoman hands; has been observed in drowning victims but this finding is not diagnostic of drowning as it is merely a sign of prolonged immersion[5].

These findings become less apparent due to onset of significant decomposition both externally and internally, prolonged passive inflow of water into the body and postmortemarte facts, especially those caused by predation by aquatic animals or fauna complicate the picture [5,6,7] and in such cases, the presence of middle ear hemorrhage act as an additional marker to diagnose death by antemortem drowning.

The probable mechanism for middle ear hemorrhage has been attributed to barotrauma, i.e. the pressure differences between the middle ear and the surrounding water which when an individual goes down in water produce a relative vacuum and this negative pressure within the closed cavity leads to inward stretching of the tympanic membrane and hemorrhages[8,9,10,11,12]. This hemorrhage has been cited as an autopsy finding in cases of death due to ante mortem drowning because it is attributed to vigorous breathing and movement which causes more water to propel inwards[13,14].

Materials and Methods

Study area and period: The prospective study was conducted on a total of 100 dead bodies in the Mortuary under the Department of Forensic Medicine and Toxicology, G.G.S. Medical College and Hospital, Faridkot, Punjab from April 2021 to October 2022

Inclusion criteria: All cases of drowning deaths brought to the mortuary.

Exclusion criteria: Cases with alleged history of direct head injury and any other forms of asphyxial deaths were excluded.

Methodology

After taking informed consent from relatives/ guardians of the deceased, Demographic information regarding the deceased including age, gender, religion, occupation, time of incidence, place of incidence, alleged cause for drowning and the circumstances of death was collected from the police and relatives. The duration, depth and medium of submersion was duly documented as available from the history and police records. The external state of the body i.e. fresh or decomposed was emphasized in documentation prior to conducting the examination.

The middle ear was opened with a chisel and five incisions were made through the petrous portion of the temporal bones. First incision started at the tip of the petrous bone and extended upto the jugular foramen. Then the groove of the transverse sinus from the jugular foramen upto where the groove of superior petrosal sinus reaches the groove of sigmoid part of transverse sinus was cut. Third line of incision started from the anterior tip of petrous bone and extended between it and the foramen ovale, laterally and slightly posteriorly upto 1cm beyond the foramen spinosum. The fourth line started at the posterior and lateral angle of middle fossa and extended from there towards the second line of incision. The fifth incision which connects lines three and four extended along the border of middle fossa and the squamous portion of temporal bone to open the osseous part. The middle ear cavity was viewed by knocking off the roof of the each side with a chisel and presence of any hemorrhage in the middle ear, petrous bone was documented **(Image 1)**

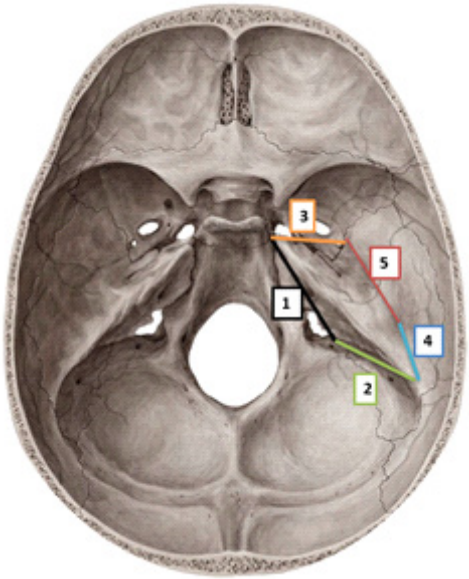

Image 1: showing the lines of incisions

Results and Discussion

Figure 1 and Table 1 show, in this study of 100 cases, 73 cases were identified and 27 were unidentified with a male to female ratio of 2.3 :1, which is in accordance with Chidanand C and Satish K.V, 2015 [11], NK Morris et al, 2015[15], Rao PS and Guntheti BK, 2021[16] and PatrickJ. Antonelli et al, 1993[17] which showed a predominance of male victims who died due to drowning.

The higher drowning rates among males may be due to being more active in the society and increased exposure to water and riskier behavior such as swimming alone, drinking alcohol before swimming alone and boating.

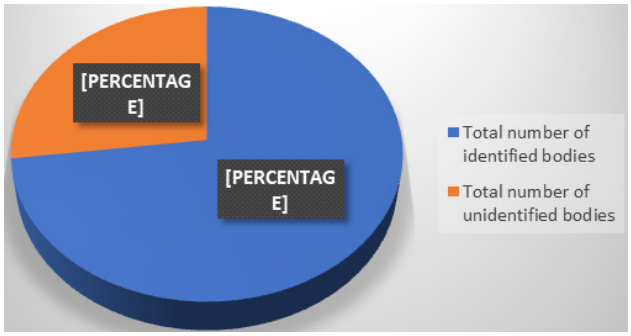

Figure 1: Represents burden of drowning deaths observed.

Table 1: Shows the Sex-wise distribution of drowning groups.

Sex	Number	Percent (%)
Males	70	70.0
Females	30	30.0
Total	100	100.0

Table 2 shows Majority of cases worked as laborers (29%), followed by private jobs(19%), 12% cases were unemployed, 8% were housewife, 5% were farmers and while in 27% cases the occupation was unknown. Rao PS and Guntheti BK, 2021[16] reported 30[44.11%] of victims were students, laborers comprised of 19[27.94%] cases and 5 victims were house- wives.

This is a study is set in rural Punjab, which is currently developing, where the underprivileged members of the society take up the job of daily wage workers and laborers who have to work in difficult terrains, including near water bodies. The insecurity of the job and low salary might be a reason for increased incidence of suicidal deaths.

Table 2: Distribution of study population according to occupation

Occupation	Frequency	Percent (%)
Farmer	5	5
Laborer	29	29
Private Service	19	19
Housewife	8	8
Unemployed	12	12
Unknown	27	27
Total	100	100

Table 3 and Figure 2 depicts around 50% of deaths occurred from July to October [maximum in September (19%), followed by July (18%), August (13%), February(12%)]. Least number of people died in month of march 1(1%).

Rainy season comprised of 57% cases, followed by winters(19%) and then summers(12%) and autumn (12%). This was in discordance with Chidan and C and Satish K.V, 2015[11], NK Morris et al, 2015[15] and Rao PS and Guntheti BK, 2021[16], who reported maximum deaths occurred in summer months, being 44%, 40% and 67.64% respectively.

Heavy rainfalls are associated with an increase in water level in canals, rivers and wetlands, and in those months, the weather is hot and humid and individuals may prefer to come out of their homes to a nearby water body to feel refreshed, to swim or

even to fill water for drinking. These increased risks, raise the number of deaths in these months.

Table. 3: Shows the Month-wise distribution of Drowning victims

Month	Number	Percent (%)
January	5	5
February	12	12
March	1	1
April	6	6
May	5	5
June	7	7
July	18	18
August	13	13
September	19	19
October	10	10
November	2	2
December	2	2
Total	100	100

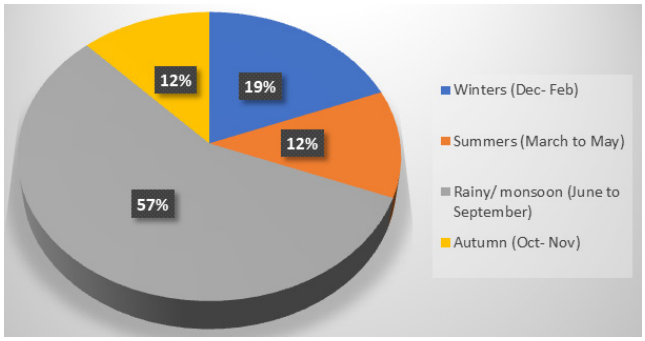

Figure 2: Shows a season- wise distribution of deaths by drowning

Table 3 shows presence of froth in 26 cases and was absent in 74 cases. It was observed that froth is mostly in present in bodies that are immersed in water for duration of 6-24 hours(97.1%). This association was statistically significant.

In comparision to the present study, Chidanand C and Satish K.V, 2015[11] saw presence of froth in 58% cases and NK Morris et al, 2015[15] recorded a plume of froth at the nostrils in 85 cases (31%). However, no correlation with increasing postmortem interval was done by both the authors. The presence of froth at nostrils and mouth is considered to be a major finding in diagnosing death by drowning and the absence of froth after 24- 48 hours in the present study indicated that with increasing submersion time, external foam is washed away or becomes so diluted with water that there is insufficient surfactant to produce external foam.

Another hypothesis is that after 24 hours surfactants can no longer function. This may be because the proteins are partially consumed or become too decayed, due to the combination of a warm and moist environment that bodies in water provide for the growth of micro organisms. Furthermore, a previous study demonstrated a poorer surfactant activity in mammals at 3 degrees Celsius than at 37 degrees Celsius. The cooling of a body after death may explain why external foam is not detected after a longer post-mortem interval. Finally, another possible explanation for the disappearance of external foam after 24 hours is the half-life of surfactants, which has been described as ranging between 6.5 and 28 hours. Hence explaining the disappearance of froth beyond 24 hours[18].

Table 3: Relationship between presence of froth and Postmortem interval

Postmortem interval	Froth				p-value
	Present		Absent		
	Number	Percent%	Number	Percent%	
<6 hours	0	0.00	1	0.01	<0.001
6 –12 hours	11	42.30	0	0.00	
12 – 24 hours	14	53.80	4	0.05	
24 – 48 hours	1	3.80	26	0.35	
2-4 days	0	0.00	8	0.11	
3-5 days	0	0.00	14	0.19	
5-10 days	0	0.00	20	0.27	
>10 days	0	0.00	1	0.01	
Total	26	100.0	74	1.00	

Table 4 shows, middle ear hemorrhage is observed in total 77% of the bodies. 43% have unilateral hemorrhage while 34% have bilateral hemorrhage. The results are in accordance with Chidanand C and Satish K.V (2015) (21) who found middle ear hemorrhage in 73 cases (72.27%) and it was unilateral in 26 (25.74%) cases, bilateral in 47 (46.53%) cases. Rao PS and Guntheti BK (2021) (71) also observed 72 % cases with middle ear hemorrhage. The presence of middle ear hemorrhage is also in confirmation with Nelson R Niles (1963), who reported it in 80.4% of cases (bilateral in 68.63% of cases and unilateral in 11% of cases). Patrick .J . Antonelli et al, 1988[17] reported bleeding into middle ear as universal in all their cases and Alhemyari et al,1988[19] documented 75% of the cases that showed intracavitary hemorrhage in temporal bones, which included 75% of the right side and 73% of the 76 left side.

Maximum cases of middle ear hemorrhage were observed in time frame of 6 hours to 5-10 days, where it was present in 13 out of 14 cases with a postmortem interval of 3-5 days and 17 out of 20 cases with a postmortem interval of 5-10 days. It was observed that even with increasing postmortem interval, middle ear hemorrhage was a persistent finding with respect to the other significant finding of antemortem drowning such as presence of froth around mouth and nostrils which disappeared after 24 to 48 hours. This meant middle ear hemorrhage can be considered a reliable indicator to diagnose death due to drowning in decomposed bodies which are retrieved after a significant time, where other findings are inadequate and inconclusive.

Table 4: Shows the presence of middle ear hemorrhage and its relationship with Postmortem interval.

Time			Middle ear hemorrhage						p-value
	Unilateral		Bilateral		Absent		Total		
	n	%	N	%	n	%	n	%	
<6 hours	0	0.0%	0	0.0%	1	100.0%	1	100.0%	.04
6 –12 hours	6	54.5%	4	36.4%	1	9.1%	11	100.0%	
12 – 24 hours	10	55.6%	3	16.7%	5	27.8%	18	100.0%	
24 – 48 hours	5	18.5%	11	40.7%	11	40.7%	27	100.0%	
2-4 days	4	50.0%	3	37.5%	1	12.5%	8	100.0%	
3-5 days	10	71.4%	3	21.4%	1	7.1%	14	100.0%	
5-10 days	7	35.0%	10	50.0%	3	15.0%	20	100.0%	
>10 days	1	100.0%	0	0.0%	0	0.0%	1	100.0%	
Total	43	43.0%	34	34.0%	23	23.0%	100	100.0%	

Table 5 shows Multiple additional antemortem injuries were present in 29 cases and among those middle ear haemorrhage was present in 16 cases (55.10%). While in cases where additional injuries were absent (n=71), middle ear haemorrhage was observed in (n=61) 85.9% cases and was absent in (n=10)14.1% cases. This association was statistically significant signifying that before drowning even if an individual experienced external bodily trauma in the form of physical abuse by a perpetrator, or injuries sustained during the fall into the water or by the rocks or projections along the banks of the flowing water or if it's a false positive finding in case of postmortem submersion, this positive finding of Middle ear haemorrhage(85.9%) in the absence of any additional antemortem injuries becomes an important factor to conclude death caused due to drowning.

Table 5: Shows the relation between Middle ear haemorrhage and multiple additional antemortem injuries

		Multiple additional antemortem injuries					P- Value
		Present (n)	Percent (%)	Absent (n)	Percent (%)	Total	
Middle ear hemorrhage	Present	16	55.1 %	61	85.9 %	77	0.002
	absent	13	44.9 %	10	14.1 %	23	
	Total	29	100.0 %	71	100.0%	100	

Conclusion

Diagnosis of drowning in bodies recovered from water remains difficult and one of exclusion and is considered one of the most difficult tasks in the field of forensic medicine. Decomposition and delay in recovery of dead bodies from the water bodies may hamper the diagnosis of death by drowning. During the process of drowning, a negative pressure is created by violent gushing of the liquid medium in and out of lungs across the nasopharynx. It causes a suction effect within the middle ear through patent Eustachian tube. In the presence of intact tympanic membrane, a pressure differential is created across the membrane (positive pressure outside and negative pressure inside). It exerts a suction force on the walls of capillaries supplying the soft tissues of tympanic membrane, middle ear, mastoid air cells and inner ear, resulting in a spectrum of findings from mere congestion and oedema to frank hemorrhages due to rupture of the capillaries. The aforesaid negative pressure from the middle ear is very effectively transmitted to the mastoid than to the inner ear. Mastoid air cells are continuous with the middle ear cavity through Aditus antrum. Whereas, the middle and inner ears are separated by two membranous windows. Hence, the hemorrhages are more common in middle ear and mastoid [10,12].

The present study focused on the presence of middle ear hemorrhage as an additional marker to diagnose death by antemortem drowning along with presence of other findings or when other findings are negligible.

Conflict of interest: None

Source of funding: Self

Ethical Clearance: Obtained from College Ethics Committee, Guru Gobind Singh Medical College, Faridkot, Punjab. Dated 28/4/2021

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