

# Medico-legal study of intracranial causes of death



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## KEYWORDS

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Laceration

**Abstract** *Background:* A lot of incidents related to the head region could lead to death, but for simplicity's sake, these incidents are mainly of two broad categories: either non-traumatic (natural) or traumatic (violent).

*Objectives:* To classify all intra-cranial lesions and injuries according to the mode and manner of death, gender, age and admission to hospital, and to evaluate these lesions and their role in the cause of death.

*Materials and methods:* The study was performed on 119 cases referred to the Medico-Legal Institute in Baghdad within the period of the study from 1 November 2012 to 1 May 2013. Complete routine autopsies were carried out for all cases with a thorough external and internal examination. Digital photography was used for some interesting cases. Tissue specimens were sent for histopathology and blood samples were drawn for alcohol and toxicology.

*Results:* Intracranial lesions accounted for 11.54% of the total deaths. The mean age was  $32.48 \pm 17.59$ . The commonest age group affected by intracranial lesions was > 20–30 years. Traumatic cases were the commonest. Males were more than females. In traumatic deaths, road traffic accidents were the commonest categories of death, while in the non-traumatic deaths cerebro-vascular accidents were the commonest category. Accidental manner of death was the commonest. Intracranial lesions alone were seen in only 27.73% of the cases. Subarachnoid hemorrhages were the commonest intracranial lesions. Pneumonia represents the commonest complication in delayed death.

*Conclusions:* Pure intracranial causes of death were recorded in a minority of cases studied. Mostly they were sharing injuries in other anatomical sites.

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## 1. Introduction

The head is the preferred target for criminal acts and is a favorite place for various pathological lesions.<sup>1</sup>

According to the World Health Organization (WHO), deaths related to the head, whether traumatic or non-traumatic, represent about 17% depending on global studies from different countries; in the United States of America (USA) cerebrovascular diseases represent the third cause of death.<sup>2</sup>

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Brain lesions could be caused by either traumatic or non-traumatic incidents. Traumatic brain injuries are caused by two mechanisms: either by impact and/or movement of the brain inside the skull.<sup>3</sup> In the USA the annual incidence of head injuries is 300 per 100,000 per year with a mortality rate of 25 for 100,000 in North America and 9 per 100,000 in the United Kingdom (UK). The most common causes of head trauma are RTA (road traffic accidents), home and occupational accidents, falls and assaults.<sup>4</sup>

Non-traumatic (natural) brain lesions could be due to increased intracranial pressure, cerebrovascular diseases, metabolic disorders, tumors of the central nervous system (CNS), neurodegenerative diseases, infections of the CNS and myelin diseases.<sup>5-7</sup>

In adults, CNS-related pathologies causing sudden death are of the following order: intracranial hemorrhages (more than 50% of the cases), seizures, neurodegenerative disorders, hypoxic-ischemic lesions with strokes, intracranial tumors, primarily CNS infections, multiple sclerosis and developmental disorders with predominance of the male gender in all age groups except for the neurodegenerative disorders (dementia disorders), which are primarily of the female gender.<sup>8,9</sup>

## 2. Method

A prospective descriptive study was performed on 119 cases from a total of 1,031 cases referred to the Medico-Legal Institute of Baghdad within the period of the study, including cases of head injuries and sudden or suspected circumstances of death.

Information about each victim was gained from police reports, close relatives of the victim, eyewitnesses, and medical reports for those who were admitted to hospital prior to death.

Decomposed bodies were excluded from the study.

The information gathered included: age, sex, medical history, mode of death and admission to hospital.

External examination of the bodies to locate and mark all external injuries and their anatomical sites and types was carried out. X-ray examination was performed on some cases when needed, then a complete classical autopsy was performed starting with the head region.

After removing the bony window, the meninges and the brain were examined for any hematomas, hemorrhages or any other lesions and abnormalities. The brain was removed and examined thoroughly; the base of the skull was examined after removing the dura to detect any fractures or pathological state. Separating the cerebellum from the cerebrum by single swap movement at its junction, the brain was sliced in two parts by the brain knife in the sagittal section to examine the ventricles and both the white and gray matter; then a coronal incision with one centimeter slices was carried out starting from the frontal lobe. The cerebellum and the brainstem were also sliced and examined. The autopsy was completed by dissecting the chest and abdominal regions to reveal any internal organ injury associated with the intracranial pathology.

### 2.1. Complementary investigations

- Tissue brain samples were taken from different brain sites or intracranial pathological lesions and from some other

organs when found and kept in 10% formalin and sent the next day for histopathological examination.

- Blood samples were drawn (about 10–20 ml) from the femoral vein for toxicology and alcohol investigations using a mixture of NaF or KFI and potassium oxalate.
- Thin layer chromatography (TLC) screening test was used for toxicology and confirmed by UV/VIS (180–820 nm) visible spectrophotometer for determination of concentration, if TLC test was positive.
- For detection of alcohol, alcohol gas chromatography (AGC) was used.
- Radiological survey for selected cases was done to reveal foreign bodies, bullets, bone injury, shells and their sites prior to autopsy.
- Digital photography was done for interesting and unique injuries and pathologies.

### 2.2. Statistical analysis

- Data were analyzed using SPSS (Statistical Package for Social Sciences), version 16 and Microsoft Office Excel 2007.

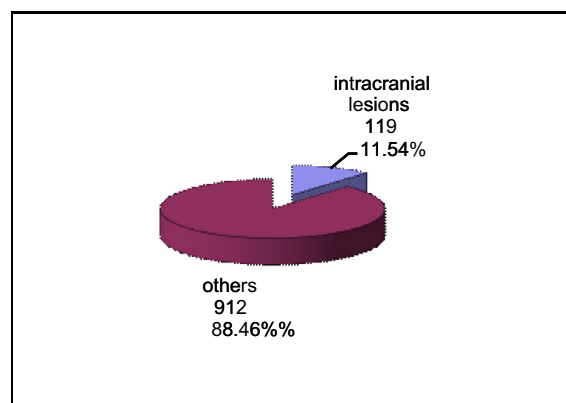
## 3. Results

A medico-legal prospective post-mortem study was carried out on 119 cases representing 11.54% of the total number of 1,031 cases referred to the Medico-Legal Institute in Baghdad during a 6-month period that started from 1 November 2012 to 1 May 2013 (Figure 1).

Eighty cases were males (67.23%) and 39 cases were females (32.77%) ranging in age between 2 months and 81 years, with a mean age of 32.48 years  $\pm$  17.59.

The commonest age group affected by the intracranial injuries was > 20–30 years accounting for 21.8%, and the least common age group affected by those injuries was > 70 years accounting for 2.5% from the total number of all cases (Table 1).

Traumatic cases totaled 89 from all cases (74.79%) with a mean age of 32.54 years  $\pm$  18.67, while non-traumatic cases were only seen in 20 cases (16.80%) with a mean age of 32.13 years  $\pm$  15.66 (see Table 2).



**Figure 1** Percentage of deaths due to intracranial lesions from total number of cases.

**Table 1** Age groups in ten-year intervals.

Age interval	Frequency	Percent (%)
< 10 years	15	12.6
10–20 years	10	8.4
> 20–30 years	26	21.8
> 30–40 years	23	19.3
> 40–50 years	18	15.1
> 50–60 years	18	15.1
> 60–70 years	6	5.0
> 70 years	3	2.5
Total	119	100.0

Male gender was predominant in 80 cases accounting for 67.2% of the total number, while female gender was seen in 39 cases (32.8%) of the total number with male: female ratio of 2:1.

In death due to trauma, RTA (road traffic accidents) were the commonest category of death represented in 35 cases followed by bullet injury, which was seen in 24 cases, and only 1 case of stab wounds was found in non-traumatic death. CVA (cerebrovascular accidents) occupies the commonest non-traumatic category and was represented in 11 cases followed by meningitis that was found in 3 cases (Table 3).

Accidental manner of death was predominant in traumatic mode and seen in 45 cases accounting for 37.8%. Homicidal

deaths were seen in 32 cases accounting for 26.9%, while suicidal deaths were the least type seen in 5 cases accounting for 4.2%. Natural deaths were seen in 20 cases (16.8%) (Figure 2).

The study showed that intracranial lesions alone were seen in 33 cases (27.73%) and mixed intracranial and extra-cranial lesions were seen in 86 cases (72.26%), while intracranial lesions with extra-cranial lesions that accompanied other body lesions were seen in 57 cases (47.89%) (Table 4) (see Photographs 1–4).

Neither skull fractures nor any extra-cranial injury were found in 60 cases accounting for 50.42%. Skull fractures and other extra-cranial injuries were found in 59 cases from the total number of cases accounting for 49.57%. Skull fractures due to head injury were seen in 39 cases accounting for 32.77% followed by bullet injuries in 25 cases accounting for 21.01%. Other types of injuries are listed in Table 5.

No associated internal organ injury was found in 83 cases accounting for 69.75%. Associated internal organ injuries were seen in 36 cases accounting for 30.25%. Spleen and lung were injured in 20 cases for each (16.81%) followed by liver in 15 cases and only a single injury was seen in the diaphragm, uterus, colon and mesenteries (0.84%) (Table 6).

Sixty-six cases were admitted to hospital (delayed death) representing about 55.5%, and 53 cases (44.5%) died instantaneously.

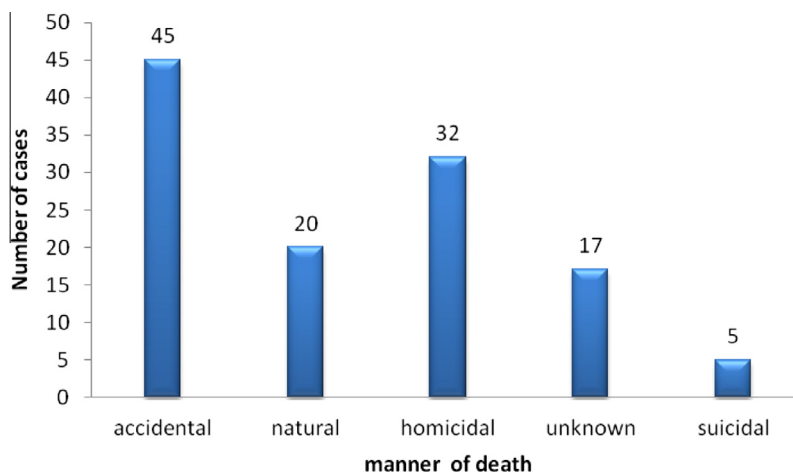
Complications were seen in 15 cases (those who were admitted to hospitals) from the total number of cases (12.61%).

**Table 2** Age and mode of death.

Mode of death	N	Percent (%)	Mean age	Std. deviation	Std. error
Trauma	89	74.79	32.5485	18.67879	2.01419
Non-traumatic	20	16.80	32.1364	15.66098	3.33893
Unknown	10	8.40	31.0000	12.48110	3.94687
Total	119	100	32.3404	17.59746	1.61998

**Table 3** Categories and mode of death groups.

	Mode of death			Total
	Traumatic	Non-traumatic	Unknown	
<i>Categories of death</i>				
Fall from height (FFH)	6	0	0	6
Tumor	0	2	0	2
Road traffic accidents (RTA)	35	0	0	35
Bullet injury	24	0	0	24
Traumatic wounds	11	0	0	11
Sudden death	0	2	0	2
Unknown	0	0	10	10
Meningitis	0	3	0	3
Bomb explosion	3	0	0	3
Heavy object fall on the head	2	0	0	2
Railway injury	2	0	0	2
Cerebrovascular diseases	0	11	0	11
Convulsions	0	2	0	2
Electric shock and fall from height	2	0	0	2
FFH and RTA	2	0	0	2
Stab wounds	2	0	0	2
		Total	89	119



**Figure 2** Manner of death.

**Table 4** Types of cranial lesions and other body lesions.

Type of lesion	No.	Percent (%)
Intracranial lesions only	33	27.73
Intracranial lesions and extra-cranial lesions	86	72.26
Intracranial lesions with extra-cranial lesions with other body lesions (gastric ulcers, wounds, etc.)	57	47.89



**Photograph 1** A well-localized intra-cerebral hematoma located at the left fronto-temporal lobe in a 35-year-old male with a history of hypertension presented as sudden death.



**Photograph 2** Massive subdural and subarachnoid hemorrhages on both sides of the cerebral hemispheres mainly at the anterior fronto-temporal lobes and part of the parietal lobes.

Pneumonia represents the commonest complication in delayed death and was seen in 6 cases (20%) (Table 7).

Subarachnoid hemorrhage was the commonest finding during autopsy and was found in 51 cases accounting for 42.68%



**Photograph 3** Ruptured brain abscess in the right fronto-temporal lobe with dispersion of suppurative fluid.



**Photograph 4** A big hematoma covering the Circle of Willis at the base of the brain.

from the total number of cases. Subdural hemorrhages were found in 41 cases accounting for 34.45% (Table 8).

No brain pathology was seen in 45 cases (37.81%). Lacerations were the commonest brain findings presented in 25 cases (21.00%) from the total number of the cases while edema was seen in 18 cases (15.13%) (Table 9).

Alcohol was detected in 7 cases (5.88%). Only 1 of them was detected in a non-traumatic injury while the other 6 positive cases were traumatic injuries.

All toxicological laboratory tests were negative for drugs, including benzodiazepines, barbiturates and antiepileptic drugs, as many victims might be under their effect during driving.

#### 4. Discussion

Intracranial injuries were found in 11.54% of all cases. This result disagreed with a study done by Holbourn in England during a period of 2 years in the neurosurgery department in the Hospital of London, in which intracranial injuries were accounting for 15% of all cases.<sup>2</sup> This difference could be attributed to the fact that Holbourn's study depends on mixed medico-legal and non-medico-legal deaths during surgery and hospital admission, while in the current study only those cases seen during autopsy were taken into account. The study coincides with a study in Austria with nearly similar results in which intracranial lesions represent 12% of all deaths.<sup>10</sup>

**Table 5** Types of cranial and extra-cranial injuries.

Type of injury	No.	Percent (%)
No injury	60	50.42
Skull fractures	39	32.77
Bullets injury	25	21.01
Traumatic wounds	14	11.76
Abrasions	14	11.76
Contusions	13	10.92
Bruises	3	2.52
Cut wounds	2	1.68
Shells	2	1.68
Recent surgical wounds	2	1.68
Tongue bites	2	1.68
Infected surgical wounds	1	0.84
Old scar of a neurosurgery in the skull	1	0.84
Recent neurosurgery scar	1	0.84
Petechial hemorrhages	1	0.84
Conjunctival bleeding	1	0.84
Electric burns	2	1.68
Dislocations	1	0.84
Wound abscess	1	0.84

**Table 6** Associated internal organ injuries.

Organ	No.	Percent (%)
No injury	83	69.75
Spleen	20	16.81
Lung	20	16.81
Liver	15	12.61
Heart	6	5.04
Kidney	4	3.36
Stomach	3	2.52
Aorta	2	1.68
Pancreas	2	1.68
Small bowel	2	1.68
Bladder	2	1.68
Diaphragm	1	0.84
Uterus	1	0.84
Colon	1	0.84
Mesenteries	1	0.84

**Table 7** Presence and type of complications.

Complications	No.	Percent (%)
Pneumonia	6	40
Myocardial infarction	3	20
Gastric ulcer	3	20
Gastroenteritis	1	6.66
Pancreatitis	1	6.66
Atrophied internal organs	1	6.66
Total	15	100

The mean age of the victims was close to the mean age of a previous study done in 2003.<sup>11</sup>

The commonest age group affected by the intracranial lesions was > 20–30 years and the least age group affected by those injuries was > 70 years. These results were in agree-

ment with a study done by Ommaya,<sup>12</sup> while there was disagreement with a study in Japan that stated that the commonest age group affected by the intracranial lesions was > 40–60 years and the least age group was < 20 years.<sup>13</sup> This is because the Japanese study was performed on only natural or pure intracranial lesions with 20-year age interval.

The majority of cases were traumatic injuries due to a high number of incidents occurring daily that were referred to be autopsied while most of the non-traumatic cases were just given a death certificate. The result is similar to previous studies.<sup>7,14,15</sup>

In males, traumatic and non-traumatic modes of death were more common than in females with no significant correlation between gender and mode of death. This result was in agreement with a retrospective study on traumatic deaths only in Brazil.<sup>16</sup>

Accidental manner in traumatic mode of death was predominant due to a high number of fatal road traffic injuries occurring daily followed by homicidal then suicidal modes of death while natural deaths were seen in a minority of cases. These results were similar to those found by other researchers.<sup>17–19</sup>

The majority of cases were with mixed intracranial and extra-cranial lesions. This was because most of them were traumatic in nature. Within the intracranial group, subarachnoid hemorrhage was followed by intra-cerebral hemorrhage. These two causes of death were seen in both traumatic and non-traumatic modes of death and coincide with previous studies.<sup>20,21</sup>

Almost half of the cases were neither as a result of skull fractures nor extra-cranial or other external injuries while skull fractures followed by bullet injuries were the commonest findings among the other half.

Associated internal organ injuries were seen in less than a third of the cases as this study focused on intracranial injuries.

Pneumonia was the commonest complication in delayed death. This could be attributed to the longer duration of admission with dependence on parental feeding due to the patient being unconscious, in addition to contamination, making the victims more liable to pneumonia.

Subarachnoid hemorrhage was the commonest finding during autopsy followed by subdural hemorrhage. These are expected as subarachnoid hemorrhage can be a cause of death in both traumatic and non-traumatic accidents while subdural hemorrhage is only traumatic in nature.

Brain laceration is a common finding in death due to head injury which reflects the severity of trauma while Edema, which comes next, could be due to natural or traumatic in origin.<sup>22,23</sup>

Almost half of the victims died instantaneously and this result is similar to a previous finding.<sup>24</sup> This reflects the seriousness and severity of injuries in this country that resulted in a higher rate of instantaneous death and the delay in the transportation of injured patients to the hospitals. On the other hand, more than half of them died later on in hospitals due to complications such as pneumonia and delayed bleeding as a result of rupture of a cerebral artery, which may happen after a variable period of time following trauma due to injury to its wall and the formation of post-traumatic aneurysm.<sup>25</sup>

There was a limited minor role for alcohol in the current study as in a previous study conducted in Saudi Arabia.<sup>26</sup> This is because of the religious and cultural background of the Islamic countries.

**Table 8** Types of meningeal pathologies.

Meningeal finding	No.	Percent (%)
Subarachnoid hemorrhage (traumatic and non-traumatic)	51	42.86
Subdural hemorrhage	41	34.45
Tears	31	26.05
No finding	18	15.13
Epidural hemorrhage	8	6.72
Meningitis	5	4.20
Thickened dura with fibrosis and presence of foci of bleeding	5	4.20
Petechial hemorrhages in the dura matter	3	2.52
Tumor deposits at dura matter	1	0.84

**Table 9** Types of brain pathology.

Brain finding	No.	Percent (%)
No finding	45	37.81
Lacerations	25	21.00
Malformations	3	2.52
Edema	18	15.13
Intraparenchymal bleeding	16	13.45
Abscess	7	5.88
Hemorrhages in the gray matter	3	2.52
Hemorrhages in the white matter	6	5.04
Intraventricular bleeding	3	2.52
Herniation	3	2.52
Tumors	2	1.68
Cysts	1	0.84
Contusions	1	0.84
Dilatation of the ventricles	1	0.84
Atherosclerosis (basilar and vertebral arteries)	1	0.84

## 5. Conclusions

Pure intracranial causes of death were recorded in a minority of cases studied. Young male adults were mostly affected and traumatic causes of death were commonly seen in both sexes. Accidental manner was mostly reported in traumatic death. Subarachnoid hemorrhage was the commonest pathology seen while lacerations were the commonest brain and brainstem lesions.

## Funding

None.

## Conflict of interest

None declared.

## Informed consent

Information about each victim was gained from police reports, close relatives of the victim, eyewitnesses, and medical reports for those who were admitted to hospital prior to death.

## Ethical approval

Necessary ethical approval was obtained from the institute ethics committee.

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