"CORRELATION OF COMPUTED TOMOGRAPHY SCAN FINDINGS WITH AUTOPSY FINDINGS IN FATAL HEAD INJURY CASES- A ONE AND HALF YEAR HOSPITAL BASED CROSS SECTIONAL STUDY"

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This is to certify that the dissertation entitled **"CORRELATION OF COMPUTED TOMOGRAPHY SCAN FINDINGS WITH AUTOPSY FINDINGS IN FATAL HEAD INJURY CASES- A ONE AND HALF YEAR HOSPITAL BASED CROSS SECTIONAL STUDY"** is a bonafide research work done by **REG NO- BF0116001.**

Dr. P.S. Jirli MD
Professor and Head
Dept. of Forensic Medicine and Toxicology,
KAHER's J. N. Medical College,
Nehru Nagar Belagavi -10.

Date:
Place: **BELAGAVI**

Dr.(Mrs) N.S.Mahantshetti MD (Paed)
Principal,
KAHER's
J. N. Medical College, Nehru Nagar,
Belagavi-10.

Date:
Place: **BELAGAVI**

LIST OF ABBREVATIONS USED

WHO	-	World Health Organisation
CT	-	Computed Tomography
CAT	-	Computed Axial Tomography
TBI	-	Traumatic Brain Injury
HT	-	Head Trauma
GCS	-	Glasgow Coma Scale
DAI	-	Diffuse Axonal Injury
LOC	-	Loss of Consciousness
MRI	-	Magnetic Resonance Imaging
PET	-	Positron Emission Tomography
NMR	-	Nuclear Magnetic Resonance
EDH	-	Extra Dural Haemorrhage
SDH	-	Sub Dural Haemorrhage
SAH	-	Sub Arachnoid Haemorrhage
ICH	-	Intra Cerebral Haemorrhage
RTA	-	Road Traffic Accident
ACF	-	Anterior Cranial Fossa
MCF	-	Middle Cranial Fossa
PCF	-	Posterior Cranial Fossa

ABSTRACT

BACKGROUND

The injury to the head is one of the most common and important aspect in Forensic practice as it accommodates most important vital organ of human body- The Brain, Master of all organs. It has become a significant public health problem and is predicted to surpass many diseases and become a major cause of death and disability by 2020. The motor vehicle accidents are the leading cause of head injury followed by falls, physical assaults, firearm wounds and others. Since the head contains brain, the most important vital organ, trauma to this region challenges the individual because of its anatomical position, size and movements in all directions. Despite improvements in safety measures in vehicles and greater availability of emergency measures, head injuries have not declined. Some of the factors that increase the risk of road traffic accidents in India are lack of people following the traffic rules, drunk driving, rash driving, poor conditions of the road, encroachment that restricts safe areas for pedestrian and young adults trying numerous stunts on the roads.

MATERIALS AND METHODS

A hospital based cross sectional study of all fatal head injury cases subjected for medicolegal autopsy to the Department of Forensic Medicine and Toxicology, Jawaharlal Nehru Medical College, Belagavi with definite history of trauma where prior CT scan head was taken during the hospitalization from January 2017 to July 2018. Further a comparative evaluation of postmortem findings of the head injuries with that of the CT scan were analyzed by using SPSS software version 25 and the results were calculated in percentages. Informed expressed consent was taken and a

pre-tested proforma specially designed for this purpose was used for collecting the information.

RESULTS

Out of 172 cases of head injury 70 cases were hospitalized, CT scan of head was done and were subjected to postmortem examination and hence these 70 cases are included in this study. The most vulnerable age group for head injury was 19-29 years. 56 (80%) were males as compared to 14 (20%) females. The most common cause of acute head trauma came out to be road traffic accidents (90%) followed by fall from height (10%). 40 cases (57.2%) were from rural background whereas 30 cases (42.8%) were from urban background. Among 63 cases of road traffic accidents, 37 cases (52.9%) were 2-wheeler riders followed by 14 cases (20%) of pillion riders while 11 (15.7%) were pedestrians. In more than half of the cases (57.2%) the head injury was suspected and CT scan was done within 4 hours of the suspected trauma to the head. In 30 cases (42.8%) survival period was 1-7 days while in 7 cases (10%) the survival period was more than a week. In 17 cases (24.3%) the patient died in less than 12 hours after doing a CT scan while in 29 cases (41.4%) they died in 2-7 days. Out of 70 cases, scalp injury was observed in 64 cases in postmortem examination but CT scan could pick scalp injury in only 31 cases so there is incongruence of 33 cases in scalp injury. Among 70 cases, skull fractures were reported in 47 cases at autopsy while CT scan could detect only 36 cases so there was disparity of 11 cases in skull fractures. 6 cases (54.5%) of exclusive basal fractures were missed alongwith 5 cases (45.5%) involving both base and vault by CT scan. The most common type of skull fractures missed by CT scan were solitary fissured fractures (5 cases) followed by 2 cases of comminuted fractures and a case of depressed fracture. 8 cases of fracture of the petrous part of temporal bone were missed alongwith 6 cases of squamous temporal bone and 3 cases of frontal bone. Anterior cranial fossa, Middle cranial fossa and Posterior cranial fossa fractures were missed in 3 cases each in CT scan as compared to Autopsy. Among the intracranial hemorrhages, subarachnoid hemorrhage was undetected in 22 cases, subdural hemorrhage was undetected in 11 cases, and extradural hemorrhage was undetected in 1 case while intracerebral hemorrhage was undetected in 3 cases. Contusions were missed in 11 cases (26.8%) by CT scan.

CONCLUSION

Autopsy being a direct visual examination of the lesions can detect more pathological findings compared to CT scan which is a virtual interpretation of intracranial lesions. CT scans are inadequate for courtroom testimony but they provide great help to the clinicians in the emergency conditions. If the evidence of trauma is based solely on CT scan reports, there is a high possibility of erroneous accusations and convictions.

KEYWORDS- Head injury, Autopsy, Computed Tomography scan, Skull fracture, Intracranial hemorrhage, Cerebral edema.

CONTENTS

SL. NO.	TOPIC	PAGE No.
1	INTRODUCTION	1-17
2	AIMS AND OBJECTIVES	18
3	REVIEW OF LITERATURE	19-27
4	MATERIAL AND METHODS	28-29
5	RESULTS	30-49
6	DISCUSSION	50-54
7	CONCLUSION	55-57
8	SUMMARY	58-60
9	BIBLIOGRAPHY	61-66
10	ANNEXURES	
	ANNEXURE I- ETHICAL CLEARANCE	67
	ANNEXURE II- CONSENT FORM	68-71
	ANNEXURE III- PROFORMA	72
	ANNEXURE IV- PHOTOGRAPHS	73-79
	ANNEXURE V- MASTER CHART	80-84

LIST OF TABLES

Table No.	Description	Page No.
1	Distribution of cases according to age and sex	31
2	Distribution of cases according to manner of injury	32
3	Distribution of cases according to place of residence	33
4	Distribution of cases according to type of victims	34
5	Distribution of cases according to time interval between the incidence and CT scan	35
6	Distribution of cases according to survival period	36
7	Distribution of cases according to time interval between CT scan and death	37
8	Comparison of scalp injury in Autopsy and CT scan	39
9	Comparison of Skull fractures in Autopsy and CT scan	39
10	Comparison of Anatomical location of Skull fractures in Autopsy and CT scan	40
11	Comparison of type of fractures at Autopsy and CT scan	42
12	Comparison of Bone involvement in fractures	44
13	Comparison of fossa involved in basal fracture	46
14	Comparison of Intracranial hemorrhage	48
15	Comparison of traumatic brain injury noted in Autopsy and CT scan	49

LIST OF GRAPHS

Graph No.	DESCRIPTION	Page No.
1	Graphical representation of cases according to age and sex	31
2	Graphical representation of cases according to manner of injury	32
3	Graphical representation of cases according to place of residence	33
4	Graphical representation of cases according to type of victims	34
5	Graphical representation of cases according to time interval between the incidence and CT scan	35
6	Graphical representation of cases according to survival period	36
7	Graphical representation of cases according to time interval between CT scan and death	38
8	Graphical representation of comparison of anatomical location of skull fractures in Autopsy and CT scan	41
9	Graphical representation of types of fractures at Autopsy and CT scan	43
10	Graphical representation of comparison of bone involvement in fractures	45
11	Graphical representation of comparison of fossa involved in basal fractures	47
12	Graphical representation of comparison of Intracranial hemorrhages	48
13	Graphical representation of comparison of traumatic brain injury	49

LIST OF PHOTOGRAPHS

Photograph No.	Description	Page No.
1	Diffuse Extravasation of blood in the scalp with comminuted fracture over the vault	73
2	Comminuted fracture over base of skull involving posterior cranial fossa	74
3	Extradural Hemorrhage present over the right parietal region	74
4	Subdural Hemorrhage	75
5	Diffuse Subarachnoid Hemorrhage	75
6	Intracerebral Hemorrhage	76
7	Sutural Fracture over Skull vault	76
8	Cerebral Edema	77
9	CT scan image depicting skull fracture	77
10	CT scan image depicting Extradural Hemorrhage	78
11	CT scan image depicting Subdural Hemorrhage	78
12	CT scan image of diffuse Subarachnoid Hemorrhage	79
13	CT scan image depicting diffuse cerebral edema	79

INTRODUCTION

The injury to the head is one of the most common and important aspect in Forensic practice as it accommodates most important vital organ of human body- The Brain, Master of all organs. According to the National Advisory Neurological Disorders and Stroke Council, head injury is defined as morbid state resulting from gross or subtle structural changes in the scalp, skull, and/or the contents of skull produced by the mechanical forces. Traumatic Brain Injury (TBI), a form of brain injury occurs when a sudden trauma causes damage to the brain.[1]

It has become a significant public health problem and is predicted to surpass many diseases and become a major cause of death and disability by 2020.[2] The motor vehicle accidents are the leading cause of head injury followed by falls, physical assaults, firearm wounds and others. Since the head contains brain, the most important vital organ, trauma to this region challenges the individual because of its anatomical position, size and movements in all directions.

Despite improvements in safety measures in vehicles and greater availability of emergency measures, head injuries have not declined. Some of the factors that increase the risk of road traffic accidents in India are lack of people following the traffic rules, drunk driving, rash driving, poor conditions of the road, encroachment that restricts safe areas for pedestrian and young adults trying numerous stunts on the roads. According to World Health Organization (WHO) 1.25 million people die because of road traffic accidents every year whereas 20 to 50 million people suffer from injuries which causes disability. Keeping this in mind if no action is taken then road traffic accidents will become the seventh leading cause of death by 2030.[3]

The early diagnosis of structural damage and initiation of appropriate treatment is of utmost importance in saving the life of patients with head injury. CT scan is commonly used as an initial diagnostic tool to look for various kinds of lesions in cases of head injury. CT scanning is said to reveal promptly, accurately and non-invasively the intracranial and parenchymal abnormalities in acute cranio-cerebral trauma that were previously recognized only at autopsy therefore CT scan of head is indispensable in the diagnosis of the various traumatic lesion and their management.

Presence or absence of some specific lesions in a CT scan like effacement of basal cisterns is an important prognostic factor. In many patients, CT scan may look normal yet the patient may have a poor Glasgow Coma Scale (GCS). When such fatal cases are subjected to postmortem examination, various new lesions are observed which were undetected in a CT scan. So at times, some disparity is observed between CT scan findings and autopsy findings. Some lesions are appreciated during postmortem examination but may have gone undetected or missed by a CT scan and vice versa.

CT scan can reveal sectional images of the complex cerebral anatomic structures in a short time, thus helping clinicians to make decisions on management; hence CT scan is a preferred imaging method to assess acute cranio-cerebral traumas. Though the CT scan is a valuable investigative mode, it requires expertise in recognizing the lesions and hence human errors are expected.

Autopsies provide confirmation, clarification and correction of antemortem clinical diagnosis and as a consequence an opportunity for clinicians to enhance their medical knowledge and diagnostic skill and apply this to all patients under their care.

Further, in developed countries, virtual autopsy is taking over conventional autopsy as a tool for postmortem examination.[4]

As far as the prognosis is concerned, it is based on the analysis of scalp injuries, skull fractures, intracranial hemorrhages, etc. but while investigating these cases small lesions should be checked properly which are difficult to be detected by CT scan.

Autopsy evaluations in humans have revealed that the extent of Diffuse Axonal Injury in mild Traumatic Brain Injuries can be identified through postmortem microscopic evaluation only and the CT scans have a tendency to miss it out. Thus this study is taken up to correlate the CT scan findings and autopsy findings in fatal head injury cases.

COMPUTED TOMOGRAPHY SCAN (CT SCAN)

The basic and the first investigation to be done in any head injury victim is CT scan. It is a method in which a 3-Dimensional image of the inside of an object is created by the computer processing. In CT scan, tomograph is the device whereas tomogram refers to the image produced. Earlier CAT (Computed Axial Tomography) or CT scan was known as EMI scan.

The first CT scan was invented by Sir Godfrey Hounsfield using the X-rays in 1967 whereas it was established in Atkins Morley hospital in England on 1st October 1971.

CT scan of the head is a very useful tool for the detection of tumors, skull fractures and intracranial hemorrhages. Tumors are indicated by hypodense structures whereas skull fractures and hemorrhages are indicated by hyperdense structures. CT scan is the most popular investigation in case of head injury as it conveys much more information about the intracranial contents than any previous technique.

Around the World, CT scan of head is the basic screening for head trauma patients. In many patients, CT scan might look normal yet the patient has poor Glasgow Coma Scale (GCS). This complicates the therapy as the underlying physiological changes leading to poor sensorium are not anatomically discernable. Though MRI scan is a better radiological tool in this situation however it is not routinely feasible in an acute head trauma patient.[5]

The primary goal of imaging the trauma patient is to quickly and accurately identify treatable lesions before secondary injury to the brain occurs. CT scan is ideally suited to evaluate patients immediately after trauma. It is widely available and permits close monitoring of unstable patients. It is very sensitive in detecting acute hematomas and depressed fractures that require emergency surgery.[6]

MECHANISM OF HEAD INJURY

Trauma to the head may result when a moving head hits against an object or when moving object hits on the head. The factors affecting the severity of head injuries are-

(1) Speed and mass of moving object
(2) Direction of force of impact
(3) Physical properties of the skull, dura, dural positions, brain and its blood vessels

There are 2 types of head injuries-

(1) Static type
(2) Dynamic type

STATIC TYPE

Head may be hit while it is stationary and unable to move because of the rigid supports, as for example, a brick falling on head of a man sleeping on a floor. Under such condition there is no relative movement of brain within the skull and no force of acceleration and deceleration acting on brain.

DYNAMIC TYPE

Majority of the injuries belongs to this group. They are of acceleration and deceleration types. The cranio-cerebral injuries due to road traffic accidents are the result of rapid deceleration when the moving head strikes an immovable object. This produces the features of distortion aggravated by brain motility. The converse is the acceleration injury when a stationary skull is struck by a moving object, eg assault.

CLASSIFICATION OF HEAD INJURY

A) Depending on the state of Dura

(1) **Closed head injury**- Here the dura remains intact irrespective of whether skull is fractured or not.

(2) **Open head injury**- Here dura is torn. The dura may be torn by penetrating injury, bone fragment or as a consequence of skull fracture.[7]

B) Depending on duration of unconsciousness and Glasgow Coma Scale (GCS)

Type	**Duration of unconsciousness**	**GCS**
Minor or Mild head injury	<30 minutes	13-15
Moderate head injury	>30 minutes and <6 hours	9-12
Severe head injury	>6 hours	8 or less

FORENSIC ANATOMY OF THE SCALP

Scalp is the covering of head and extends from eyebrow anteriorly to superior nuchal line posteriorly and laterally from one temporal line to the other. Superficially, the skin carries hair follicles, sebaceous glands and sweat glands. The skin is attached to the aponeurosis by vertical strands of fibrous tissue that break up the subcutaneous layer into pockets filled with fat. The blood vessels and nerves lie in this layer, above the epicranial aponeurosis (formerly called the Galea aponeurotica). This is a dense sheet of fibrous tissue that lies in the deep layer of the scalp over the whole cranium.

Deep to the aponeurosis is a thin layer of loose connective tissue that separates it from the pericranium, which is the exterior periosteum of the skull, the dura being the internal counterpart. Some veins traverse all the layers from the superficial fascia to the pericranium and go on to penetrate the skull and communicate with the intracranial venous sinuses, thus forming a route for meningitis and sinus thrombosis from infected injuries of the scalp.

Thus scalp is composed of-

(1) Skin

(2) Connective tissue

(3) Aponeurosis (Galea aponeurotica)

(4) Loose areolar tissue

(5) Pericranium (Periosteum)

BRUISING OF SCALP

The contusions of scalp often result from the crushing of soft tissues against the underlying bone. The bruising may be difficult to detect until the hairs has been removed. Marked swelling is a common feature of extensive bruising as the liberated blood cannot extend downward because of the rigidity of the underlying skull. However this subsides or atleast diffuses after death. Commonly a severe head injury leads to a thick, swollen, indurated layer of blood beneath the scalp which may extend over a wide area.

A bruise in the anterior scalp may shift downward to appear around the eye thus causing "Black eye" or spectacle hematoma. A contusion in temporal scalp may shift downward and appear behind the ear- similar to battle sign. These shifting bruises are also called as ectopic contusions or percolated bruises or migratory contusions.

LACERATION OF SCALP

Lacerated wounds of the scalp may result from the splitting of the soft tissues against the underlying bone or from the tearing of the tissues by fragments of fractured bone. The lacerations of the scalp bleed profusely, and dangerous and even fatal blood loss can occur from an extensive scalp injury. The most gross injury is avulsion of a large area of scalp, which can be torn from the head thereby exposing the aponeurosis or skull. This may happen if the hairs become entangled in machinery. A more common cause nowadays is a road traffic accident where a rotating vehicle tyre comes into contact with the head causing a flaying injury similar to that seen on limbs. Lacerated wounds of the scalp are often linear in shape and may resemble incised wounds.

BLACK EYE

It is the bruising of the eyelid, i.e., periorbital area. The usual periorbital hematoma or black eye is caused by a direct punch or kick into the eye socket, but the Forensic pathologist must always consider the several alternative explanations. A black eye may be the result of-

(1) Direct trauma, which may or may not be associated with abrasion or laceration on the upper cheek, eyebrow, nose or other part of the face.
(2) Gravitational seepage of blood beneath the scalp from a bruise or laceration on or above the eyebrow.
(3) Percolation of blood into the orbit from a fracture of the anterior cranial fossa of the base of skull.

The hemorrhage in soft tissue around the eyes in eyelids of both eyes is called spectacle hematoma or raccoon eyes, i.e. in other words black eye in both side is a spectacle hematoma. It usually suggests fracture of base of skull.[7]

FORENSIC ANATOMY OF SKULL

In broader sense the bones of head are collectively known as calvaria (cranium, skull). Thus it can be considered as brain-pan excluding the bones of face. Skullcap or calva is roof of skull often called as vault. The rest part is base of skull. In adults, skull consists of two parallel tables of compact bones. The outer table is twice in thickness that of inner table. Both outer and inner table of bones are separated by a soft cancellous bone- the diploe.

The cranium varies in thickness in adults and varies from place to place, thin plates being reinforced by stronger buttresses, such as the petrous temporal, greater wing of the sphenoid, the sagittal ridge, the occipital protuberance and the glabella. The more vulnerable thin areas lie in the parieto-temporal, lateral frontal and lateral occipital zones. The average frontal and parietal thickness is 6-10 mm and temporal bone is 4 mm, and the occipital bone in midline is 15 mm or more.[7]

MECHANISM OF SKULL FRACTURE

As per Rowbotham's hypothesis, fracture of skull is caused-

(1) By direct application of force to skull, eg. Blow over head with iron rod.
(2) By indirect violence, eg. Fall from height on feet or buttock.

SKULL FRACTURES

The types of skull fractures are-

A) Fracture of vault of skull
   (1) Linear or Fissured
   (2) Depressed (Signature)
   (3) Comminuted (Mosaic or Spider web)
   (4) Pond or indented
   (5) Gutter
   (6) Diastatic or Sutural
   (7) Perforating
   (8) Cut fracture
   (9) Elevated

B) Fracture of base of skull (Basilar fracture)

(1) Linear or Fissured

(2) Ring

(3) Hinge

(4) Longitudinal

(5) Secondary

- **LINEAR OR FISSURED FRACTURE**

This is the commonest type of fracture which may involve outer or inner or both table of skull. Such fracture can be straight or curved. In children or young person, the linear fracture may pass into a suture line and causes diastatic fracture.

- **DEPRESSED FRACTURE**

It is also called as signature fracture or fracture a la signature as the pattern resembles that of causative weapon. It is a fracture in which the fractured bone is driven inwards into the skull cavity. It is typically produced by heavy weapons with small striking surface eg. Hammer and the shape of the fracture “mirrors” the striking surface of weapon. Medicolegally they are very important as they can reveal the weapon.

- **COMMINUTED FRACTURE**

It is a fracture in which two or more intersecting lines of fracture divide the bone into three or more fragments. The causative factors are fall from height on a hard surface, vehicular accident and weapon with large striking surface. It often resembles a spider’s web or mosaic.

- **<u>POND FRACTURE</u>**

This is not a true fracture and occurs only in skull of infants. Here there is dent (dimple like) formation over the skull and the dent resembles like that of concave pond. Due to pliable bones of infant, the force applied produce depression without fracture. The depression of bone is comparable with distortion produced by squeezing a table tennis ball or ping pong ball.

- **<u>GUTTER FRACTURE</u>**

It is formed when part of the thickness of skull bone is removed so as to form a gutter or furrow (or channel or trench) in the bone. They are caused when weapon strikes the skull tangentially, eg. Glancing bullet injury.

- **<u>SUTURAL OR DIASTATIC FRACTURE</u>**

Here the fracture occurs along the line of sutures of skull. It commonly involves sagittal suture and caused by blunt trauma. It usually occurs in children and young adults because of non-fusion of sutures and results in separation of skull sutures.

- **<u>PERFORATING FRACTURE</u>**

Here the skull is perforated by a sharp pointed object or bullet. The fracture involves injury to outer and inner table of skull and shape and size may correspond to the dimensions of offending agent.

- **<u>CUT FRACTURE</u>**

This fracture involves either outer table or both tables. If involved both tables, it will cause clean cut gap corresponding with the thickness of blade. If involved outer table, it is labelled as partial cut fracture. These fractures are accompanied with sharp weapons like sword or chopper.

- **RING FRACTURE**

  This is a fissured fracture that occurs round the foramen magnum in posterior cranial fossa. It occurs due to-

  (1) Fall from height and person landing on the feet or buttock

  (2) Severe impact on vertex that may drive skull downwards on the spinal column

- **HINGE FRACTURE**

  It is a linear fracture that passes across the floor of middle cranial fossa, often following the petrous temporal or great wing of sphenoid bone into pituitary fossa on both sides thus separating the base of skull into two halves. It is caused by heavy blow or impact on the side of the head. The fracture is also called as motorcyclist's fracture.

COMPLICATINS OF SKULL FRACTURE

(1) Injury to brain

(2) Intracranial hemorrhage

(3) Intracranial infections- meningitis/ encephalitis

(4) Cranial nerve injury

(5) CSF otorrhea

(6) Cranial pneumatocele or pneumocranium

(7) Cerebral edema

(8) Increased intracranial pressure/ tension

(9) Coma

FORENSIC ANATOMY OF MENINGES

The brain is covered by 3 layers and from outwards to inwards they are-

(1) Dura mater

(2) Arachnoid mater

(3) Pia mater

- Dura is composed of 2 layers; the outer layer is attached to the skull internally and acts as internal periosteum. The meningeal (dural) arteries are situated between outer layer of dura and skull.
- Arachnoid is thin vascular membrane closely associated with pia.
- Pia mater is an inseparable membrane covering the brain.
- Epidural space or extradural space is a space between dura and skull and contains meningeal (dural) arteries.
- Subdural space is a space between dura and arachnoid. The cerebral veins cross this space to reach the sinuses. Thus the parts of veins in this subdural space are called as bridging veins. The largest bridging vein is the Great vein of Galen.
- Subarachnoid space is a space between arachnoid and pia. It contains blood vessels that enter and exit the brain and cranial nerves. The space is filled with CSF.[7]

INTRACRANIAL HEMORRHAGE

Intracranial hemorrhages are of following types-

(1) Extradural or epidural

(2) Subdural

(3) Subarachnoid

(4) Intracerebral

(5) Intraventricular

- **EXTRADURAL HEMORRHAGE (EDH)**
    - It is a hemorrhage that occurs in the epidural space between the skull and dura. It is also called as epidural hematoma or subperiosteal hemorrhage.
    - The most common site is unilateral in a temporo-parietal area, caused by rupture of middle meningeal artery while the most common cause is mechanical trauma.
    - It is suggested that volume of 35 ml is needed for clinical signs to appear and a volume of 100 ml EDH is considered as fatal.
    - MLI- It is associated with lucid interval and may be confused with heat hematoma and alcohol intoxication.
- **SUBDURAL HEMORRHAGE (SDH)**
    - It is the collection of blood in the subdural space, i.e. between dura and arachnoid membrane.
    - The most common site is lateral aspect of cerebral hemisphere.

- It can be caused by either trauma due to rupture of bridging veins and dural venous sinuses or it can be pathological due to rupture of aneurysm and hypertensive bleed.
- It is common lesion than EDH and 35-100 ml is required to cause neurological signs.
- MLI- Lucid interval is present while clinical symptoms may be mistaken for schizophrenia, pre senile or senile dementia.

- **SUBARACHNOID HEMORRHAGE (SAH)**
  - It occurs in the subarachnoid space, i.e. between the arachnoid and pia mater and is the most common intracranial hemorrhage.
  - It may be caused due to trauma or may be due to pathological causes. The traumatic causes are laceration of brain, cortical contusion, blow on neck causing the laceration of vertebral artery, severe hyperextension of head while pathological causes are saccular aneurysm, arteriovenous malformations and bleeding dyscrasias.
  - MLI- A trauma may precipitate the rupture of aneurysm.
- **INTRACEREBRAL HEMORRHAGE**
  - Here the hemorrhage occurs in cerebral tissue. It is also called as parenchymatous hemorrhage.
  - It may be traumatic or non-traumatic in origin. The traumatic causes are laceration of brain and blunt trauma with or without fracture while non-traumatic (pathological) causes are hypertension, arteriovenous malformation and bleeding into cerebral neoplasm.[7]

AIMS AND OBJECTIVES

To correlate the Computed Tomography scan findings with the Autopsy findings in fatal head injury cases.

REVIEW OF LITERATURE

A study on correlation of Computed Tomography and Autopsy findings of cranio-cerebral injuries sustained in road traffic accidents was conducted on 65 cases in which 59 were males and 6 were females. The majority of victims were in the age group 21-30 years and predominantly males. During autopsy skull fractures were observed in 86% of cases. The vault of the skull (68%) was the commonest region involved with fracture followed by base of skull (14%) whereas both the base and the vault were involved in 18% of cases. The most common fracture was the fissured fracture (78%) followed by depressed (14%) and comminuted fracture (7%). The commonest region of the base of skull involved in fracture was the Middle Cranial Fossa (52%) followed by Anterior Cranial Fossa (28%) and Posterior Cranial Fossa (20%). The autopsy findings of their study were in concurrence with the findings of CT scan in 38% of cases whereas in 48% of cases the fracture was observed at autopsy but not in the CT scan. Among intracranial hemorrhage, SAH (44%) and SDH (41%) were observed in majority of cases in autopsy whereas EDH and intracerebral hemorrhage were found in 13% and 2% respectively. In 72% of their cases there was a concurrence between the findings of autopsy and CT scan whereas in 23% of cases intracerebral hemorrhage was observed during autopsy but not in CT scan. Brain lesions were found in 92% of cases during the autopsy. The autopsy and CT scan findings were in concurrence in 88% of cases whereas in 5% of cases CT scan could not detect any lesions of the brain but detected at autopsy.[8]

In a study on correlation of CT scan with postmortem findings of acute head trauma cases it was found that among 140 cases majority were males (122 cases) and of age group 21-30 years. The main cause of injury was road traffic accidents (62%)

followed by fall from height (31%). Out of 140 cases, 16% didn't had bony injury while 84% presented with fractures of skull. In CT scan no bony injury was reported in 58 cases contrary to the autopsy findings where the skull bones were found intact only in 22 cases out of total 140 cases.[9]

A comparative study on 50 head injury cases was conducted to evaluate CT scan and postmortem examination findings. 76.3% of skull fractures were diagnosed in both CT scan and autopsy findings whereas 23.7% of them remained undiagnosed by CT scan. 66.7% EDH were diagnosed in both CT scan and autopsy whereas 33.3% of them remained undiagnosed by CT scan. SDH were diagnosed in both CT scan and autopsy and no mismatch was detected. 64.3% SAH were detected in both CT scan and autopsy whereas 35.7% of them remained undetected by CT scan. Similarly in case of intracerebral hemorrhage, contusion, laceration and cerebral edema were undetected in CT scan in 30%, 20%, 16.7% and 16.7% cases respectively.[10]

A study of comparison between CT scan and autopsy findings of head injury victims was conducted on 45 cases in which 39 were males and 6 were females. Majority of cases were in age group 41-50 years. EDH was detected only in 5 cases on CT as compared to 14 cases on autopsy (detection rate- 35.7%). Traumatic SDH was detected only in 18 cases of 43 cases at autopsy (detection rate- 41.86%). SAH was detected only in 16 cases of a total of 36 cases (detection rate- 44.44%). Cerebral edema had a marginally better detection rate of 62.79% (27 of 43 cases had a positive CT findings). Fractures were evaluated as basal skull fracture and non-basal skull fractures. Amongst the skull fractures, 10 out of 27 cases were detected on CT (detection rate- 37.04%). CT had a marginally better detection rate of 48.39% with respect to non-basal skull fracture detecting 15 of 31 cases on autopsy.[11]

A study was conducted on 200 cases of head trauma revealed that males outnumbered females and the majority of deaths were due to road traffic accidents. In 184 cases, complete accordance were found between the autopsy findings and CT scan findings. However there was no accordance in rest 16 cases.[12]

A comparative study of CT scan finding and autopsy findings in 43 head injury cases was conducted in which 40 were males and 3 were females. It was found that in all cases edema and laceration that were detected on CT scan were also detected on autopsy. In 20 out of 34 cases, contusions were detected while in rest 14 cases out of 34, contusions were not detected on CT scan. Out of 43 cases, skull fractures were detected in 11 cases on CT scan however during autopsy skull fractures were detected in total 17 cases. Out of 43 cases, 4 cases of EDH were found which were detected both on CT scan and on autopsy. In case of SDH, a total of 34 cases were detected on autopsy while CT scan detected only 26 cases and 8 cases remained undetected. Similarly in case of SAH out of 43 cases, 29 cases with SAH were detected on autopsy while CT scan could detect only 21 cases and 8 cases remained undetected.[13]

A comparative evaluation of clinical and autopsy findings in 65 head injury cases revealed that both CT scan and autopsy findings concurred in skull fractures in 25 cases but autopsy detected skull fractures in 31 cases. In intracranial hemorrhage both CT scan and autopsy findings concurred in 47 cases but in 15 cases only autopsy could detect. Both autopsy and CT scan detected brain lesions in 57 cases while it remained undetected in 3 cases.[14]

A study of sensitivity and specificity of CT scan in revealing skull fractures in medicolegal head injury cases was conducted on 60 cases. Most of the victims were male and were in their 2^{nd} decade followed by 31-40 years of age group. Skull fractures were noted in 41 and 35 cases of autopsies and CT scans respectively. Of the skull fractures, 14.6% were missed on CT scans compared to autopsies.[15]

A study of fallacies of routine CT scan in identifying lesions in severe head injury was conducted on 60 cases of which 49 were males and 11 were females. Traumatic SAH was detected in CT scans of only 10 patients but was found in 33 cases at autopsy. CT scan revealed thin subdural hematoma in 5 cases while autopsy showed it in 15 cases. 4 cases were found to have EDH at autopsy while it was detected on CT scan in 3 cases. Autopsy of the brain stem revealed contusions in 30 patients, however only 6 could be appreciated by CT scan.[16]

A comparative analysis of findings of postmortem CT scan and traditional autopsy in traumatic deaths was done on 77 cases. Males outnumbered females and road traffic accidents were the most common cause of deaths. Postmortem CT was equally sensitive in detecting intracerebral bleed except for SAH that was picked up better by traditional autopsy. The traditional autopsy was also found better in detecting the soft tissue injuries.[17]

A retrospective study was conducted on 56 cases comprising 43 males and 13 females. 6 cases of SAH and 4 cases of SDH were undetected on CT scan. 9 cases of contusion, 5 cases of lacerations and 4 cases of edema were undetected by CT scan. They stated that CT scan cannot substitute the autopsy but the CT scans serve as an invaluable supplement to the autopsy.[18]

A study was conducted to analyze all traumatic deaths autopsied at Bexar County Medical Examiner's Office in which perimortem medical imaging (CT scan) was performed to assess the reliability of CT scan in detecting trauma with sufficient accuracy for courtroom testimony. The sensitivity of the CT scan ranged from 0% for cerebral lacerations, cervical vertebral body fractures, cardiac injury and hollow viscus injury to 75% for liver injury. This study revealed that CT scans are an inadequate detection tool for forensic pathologists, where a definitive diagnosis is required because they have a low level of accuracy in detecting traumatic injuries. CT scan can be a helpful tool for a clinician in casualty but its insufficient for a court of law. If the CT scan report is the only evidence for a trauma victim then there can be faulty accusations and convictions.[19]

In another study of 140 acute head trauma cases, males outnumbered females and the majority of cases were seen in 21-30 years age group. The most common cause of injuries was road traffic accidents followed by fall from height. 30 cases had temporal bone fracture as observed by autopsy whereas CT scan could appreciate it in only 27 cases.[20]

A study revealed that the larger fractures were easily detected by CT scan but the problem arises in the detection of hairline fractures. This incongruity should be taken care of in order to use the data of CT scan for trauma analysis.[21]

In a study of orbitocerebral injury by bicycle brake handle the intracranial lesions were detected more accurately by autopsy findings as compared to the CT scan findings.[22]

Subarachnoidal cisterns are enlargements filled with increased volumes of CSF. The modern micro neurosurgery emphasizes dissecting the arachnoid membrane and opening the subarachnoid cisterns in an orderly manner to gain a natural pathway through which most operations can be performed non-invasively. Furthermore, the basal cistern status can provide valuable information for predicting the prognosis of cranio cerebral traumas. The relevant anatomic study on the basal cisterns like shape and extent has to be done by autopsy to correlate the same in CT scan.[23]

A retrospective study on pattern of head injury cases in fatal road traffic accidents was conducted. Out of 321 cases of fatal road traffic accidents, 267 cases died due to head injuries. Males outnumbered females and majority of the cases were in age group 20-30 years. The maximum number of cases occurred during 6 pm to midnight. This can be due to lack of street lights, tendency to fall asleep and drunk driving. The skull fractures were seen in 52% cases and the most common type was fissured fracture. Subdural hemorrhage (45.5%) was the commonest type of intracranial hemorrhage followed by extradural hemorrhage (32.6%).[24]

A prospective study on pattern and distribution of head injuries in victims of fatal road traffic accidents was cconducted. Out of 106 cases, 98 were males and 8 were females. Most of the victims were in age group 30-40 years. The most common type of fracture in vault of skull was linear fracture (62%). Considering the involvement of fossa in base of skull, middle cranial fossa was most affected (51%). Subarachnoid hemorrhage was the most common type of intracranial hemorrhage followed by subdual haemorrhage.[25]

A descriptive study of head injury and its associated factors was conducted on 84 cases. The most common cause of death was road traffic accidents (92.8%)

followed by fall from height (3.6%). The majority of the cases were males (81%) and in age group 21-30 years. The most common type of skull fracture was linear fracture. The middle cranial fossa was the commonest region involved followed by posterior cranial fossa. Of the 78 cases of road traffic accidents, 51.3% were 2-wheeler occupants while 37.2% were pedestrians.[26]

A cross sectional study on pattern of head injuries was conducted on 50 cases comprising of 88% males and 12% females. Most of the victims were from age group 31-40 years. The most common type of intracranial hemorrhage was subdural hemorrhage followed by subarachnoid hemorrhage. Fissured fracture and comminuted fracture were the most common type of skull fractures.[27]

In a study the comparison was done between cross sectional morphological features of the basal cisterns and CT images as the changes in basal cistern helps in early diagnosis and management of acute cranio-cerebral traumas. The successive thin layer cross sectional images of the basal cistern were retrieved from the second Chinese Visible Human (CHV) data set and observed. A total of 40 healthy volunteers were subjected to 64 slice spiral CT scan of head and the CT images of basal cistern were compared with CVH images. A total of 413 patients with acute cranio-cerebral traumas were subjected to 64 slice spiral CT scan of head and the CT image changes of basal cistern were observed. Thin layer cross sectional images of the basal cistern retrieved from CVH data set correspond satisfactorily to CT images of basal cistern. The comparison of two types of images can provide a sectional anatomic basis for the image identification of acute cranio-cerebral traumas. A careful observation on the initial CT images of the basal cistern for anatomic morphological changes will help diagnose acute cranio-cerebral traumas early, improve the management and appropriately predict the prognosis of the condition.[28]

A study was conducted on 391 head injury cases comprising of 263 males and 128 females. Majority of the victims were in age group 21-30 years. The most common cause of death was road traffic accident followed by fall from height. Fissured fracture was the most common type of skull fracture while subdural and subarachnoid hemorrhage were the most common type of intracranial haemorrhages.[29]

A prospective study on pattern of head injury was conducted on 500 cases comprising of 383 males and 117 females. The majority of cases were in age group 21-30 years and the most common cause was road traffic accident followed by fall from height. The most common intracranial hemorrhage was Subdural hemorrhage and the most common bone involved in skull fractures was temporal bone. Road traffic accident remains the most common cause for head injury and demands proper investigation such as CT scan on time and good neurosurgical care for such patients.[30]

A study was conducted on pattern of fatal blunt head injury on 189 cases in which 167 were males while 22 were females. Most of the cases were in age group 20-30 years. Most of the victims of road traffic accidents were pedestrians. Fissured fracture was the most common type of skull fracture while Subarachnoid hemorrhage was the commonest type of intracranial haemorrhage.[31]

A study was conducted which reveals that CT is a sensitive tool for the detection of major injuries and cause of death accidental blunt trauma. In non-accidental traumatic deaths, CT can be a valuable adjunct to mandatory autopsy for detecting injuries.[32]

A retrospective study of 33 cases was conducted in which it was found that there was consensus agreement that SAH was recognized on the MDCT in 2 of the 6 cases. A basic shortcoming of virtopsy or virtual autopsy is that it misses the small lesions or small hematomas which are very useful in the prognosis of head trauma victims.[33]

MATERIALS AND METHODS

SOURCE OF DATA

All fatal head injury cases subjected for medicolegal autopsy to the Department of Forensic Medicine and Toxicology, Jawaharlal Nehru Medical College, Belagavi with definite history of trauma where prior CT scan head was taken during the hospitalization.

STUDY DESIGN

Hospital based cross-sectional study.

STUDY PERIOD

19 months, i.e. from January 2017 to July 2018

SAMPLE SIZE

The sample size is given by the following formula-

$$n = \frac{z^2 \times Sn(100-Sn)}{d^2 \times PR}$$

$$= \frac{1.96 \times 1.96 \times 76 \times 24}{1 \times 1 \times 100}$$

$$= 70$$

where, n= Sample size, Z= 1.96, Sn= Sensitivity, d= error, PR= Prevalence Rate

METHOD OF COLLECTION OF DATA

All fatal head injury cases subjected for postmortem examination where antemortem CT scan reports were available were taken up for the study. A detailed dissection and examination of the head of each case was done as per the standard autopsy procedure and the various types of injuries to the scalp, skull bones, hemorrhages and traumatic injuries to the brain were recorded and photographed. The CT scan reports of the deceased were collected from the Radio diagnosis department and discussed with the Radiologist. Further a comparative evaluation of postmortem findings of the head injuries with that of the CT scan were analyzed by using SPSS software version 25 and the results were calculated in percentages.

INCLUSION CRITERIA

All medicolegal cases of head injury with a definite history of trauma, admitted, undergone CT scan head and Postmortem examination at Jawaharlal Nehru Medical College, Belagavi were included in the study.

EXCLUSION CRITERIA

(1) Brought dead cases

(2) Decomposed dead bodies

(3) Dead bodies with no specific history

ETHICAL CLEARANCE

The study was approved from Institutional Ethics Committee for Human's Subject Research, Jawaharlal Nehru Medical College, Belagavi.

RESULTS

The present study titled "Correlation of Computed Tomography scan findings with Autopsy findings in fatal head injury cases" was carried out on head injury cases subjected for postmortem examination to the Department of Forensic Medicine and Toxicology, J.N. Medical College, Belagavi and the comparative evaluation was done with the antemortem CT scan reports provided by Radio diagnosis department.

Deaths due to head injury constituted 64% (172 cases) of the total autopsies (269 cases) conducted during the study period. Out of 172 cases, 70 were hospitalized and a CT scan of head was done and were subjected to postmortem examination. The remaining 102 cases died either on spot or on the way to hospital or in a hospital before a CT scan could be done.

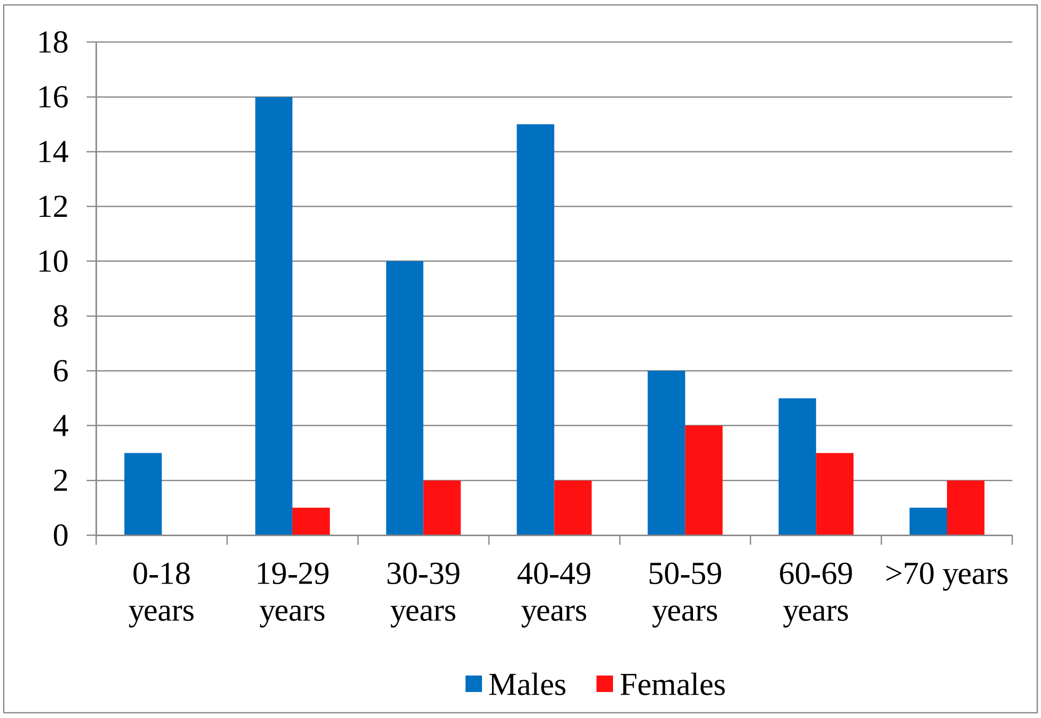
In our study out of 70 cases, 56 (80%) were males while 14 (20%) were females as depicted in Table 1 and Graph 1. Males outnumbered females because males are more into the outdoor activities like driving vehicles, working outdoors posing them risk due to accidents whereas females succumbed mainly to either accidental falls at their residence or due to road traffic accident in which they were pillion riders.

The most vulnerable age groups in our study were 19-29 years (24.3%) and 40-49 years (24.3%) followed by 30-39 years (17.1%) as shown in Table 1 and Graph 1. The obvious reason being that they form the work group and hence are prone to road traffic accidents, falls and assaults which are one of the major cause of head injury.

<u>Table 1</u>- Distribution of cases according to age and sex

Age group	Males	Females	Total	Percentage
0-18	3	0	3	4.3
19-29	16	1	17	24.3
30-39	10	2	12	17.1
40-49	15	2	17	24.3
50-59	6	4	10	14.3
60-69	5	3	8	11.4
>70	1	2	3	4.3
Total	56	14	70	100

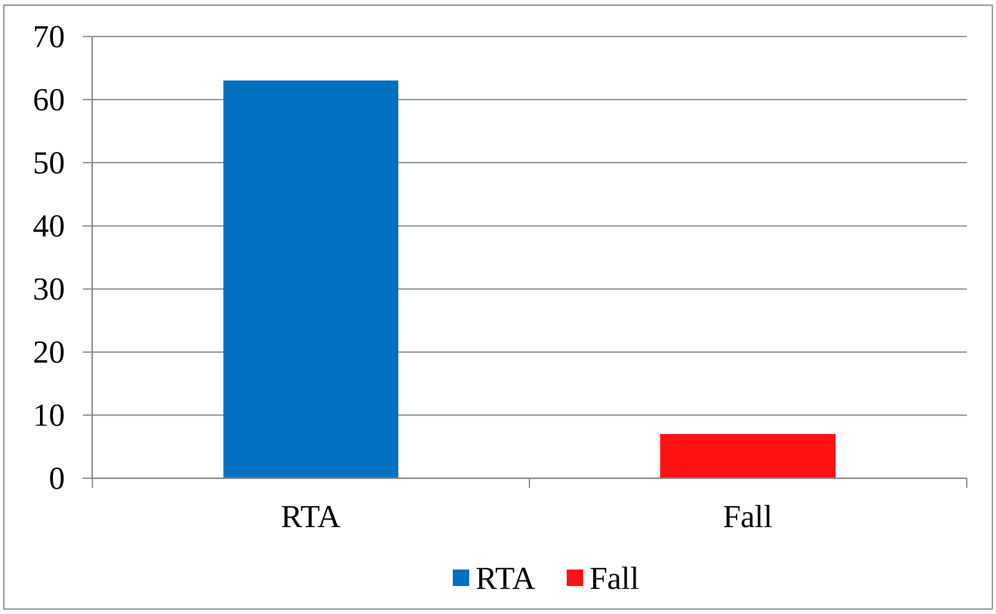
<u>Graph 1</u>- Graphical representation of cases according to age and sex



<u>Table 2</u>- Distribution of cases according to manner of injury

Manner of injury	Number of cases	Percentage
RTA	63	90
Fall	7	10
Total	70	100

<u>Graph 2</u>- Graphical representation of cases according to manner of injury

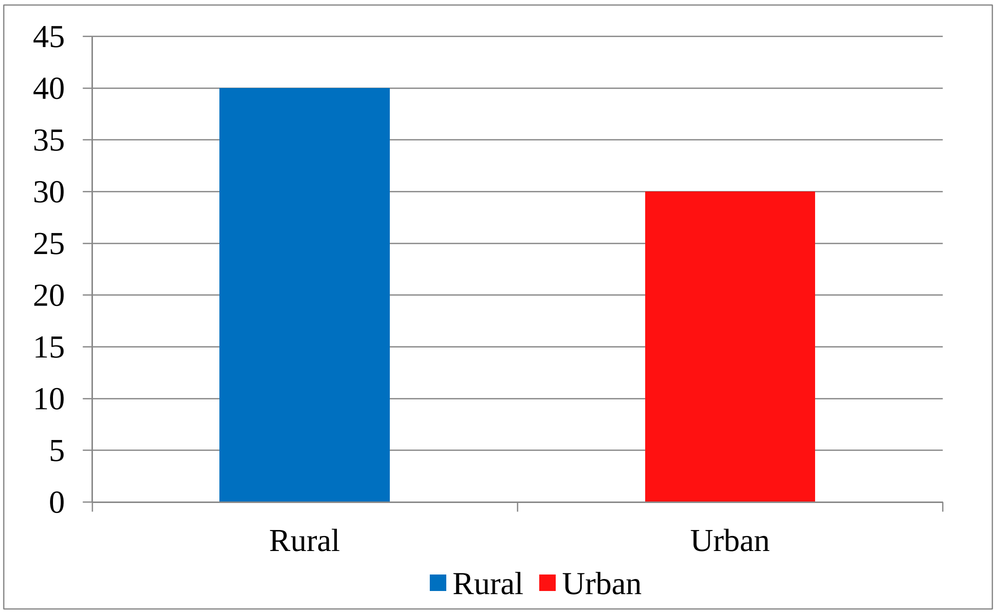


Out of 70 cases, 63 cases (90%) were due to road traffic accident while 7 cases (10%) were due to fall from height as shown in Table 2 and Graph 2.

<u>Table 3</u>- Distribution of cases according to place of residence

Place of Residence	Number of cases	Percentage
Rural	40	57.2
Urban	30	42.8
Total	70	100

<u>Graph 3</u>- Graphical representation of cases according to place of residence



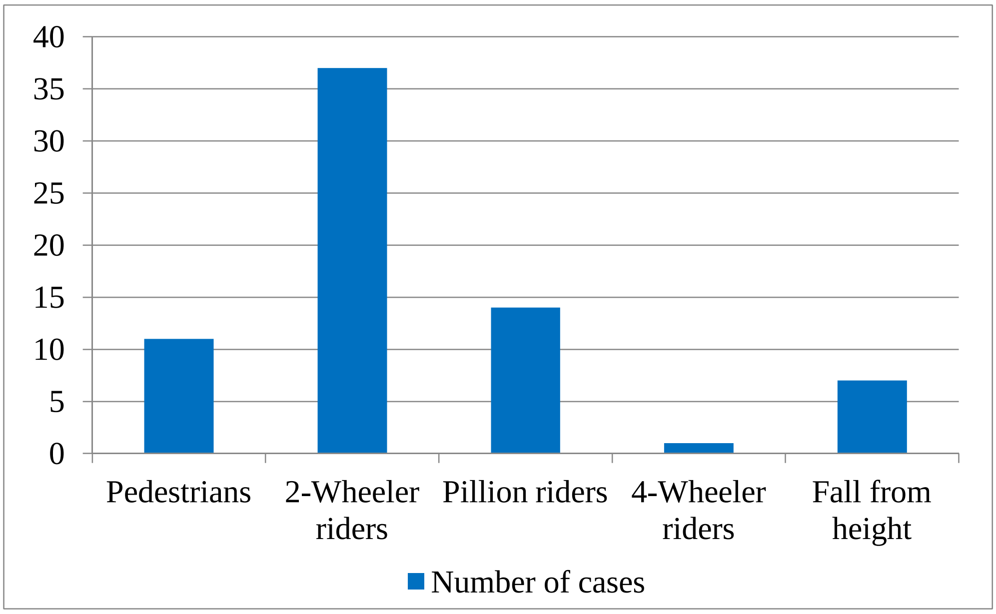
40 cases (57.2%) were from rural background as compared to 30 cases (42.8%) who were from urban background as shown in Table 3 and Graph 3.

Among 63 cases of road traffic accidents, 11 (15.7%) were pedestrians, 37 (52.9%) were two wheeler riders, 14 (20%) were pillion riders and 1 case (1.4%) was four wheeler rider whereas 7 cases (10%) were fall from height as shown in Table 4 and Graph 4.

Table 4- Distribution of cases according to type of victims

Type of Victim	Number of cases	Percentage
Pedestrians	11	15.7
2-Wheeler riders	37	52.9
Pillion riders	14	20
4-Wheeler riders	1	1.4
Fall from height	7	10
Total	70	100

Graph 4- Graphical representation of cases according to type of victims

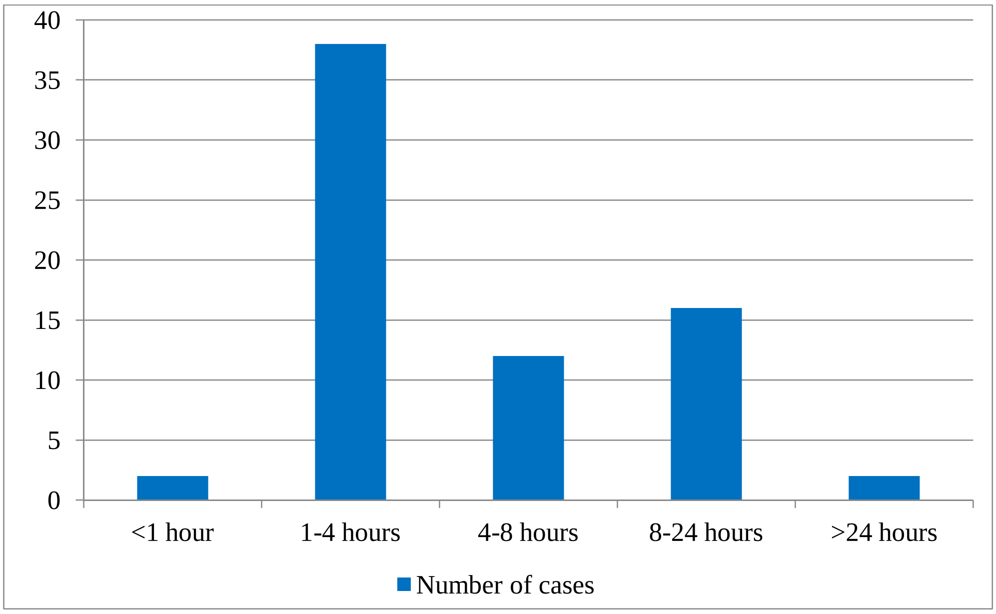


In 38 cases (54.3%), the head injury was suspected and CT scan was done in 1-4 hours of the incidence while in 12 cases (17.1%) the CT scan was done in 4-8 hours and in 16 cases it was done in 8-24 hours (as shown in Table 5 and Graph 5).

Table 5- Distribution of cases according to time interval between the incidence and CT scan

Time interval	Number of cases	Percentage
<1 hour	2	2.9
1-4 hours	38	54.3
4-8 hours	12	17.1
8-24 hours	16	22.8
>24 hours	2	2.9
Total	70	100

Graph 5- Graphical representation of cases according to time interval between the incidence and CT scan

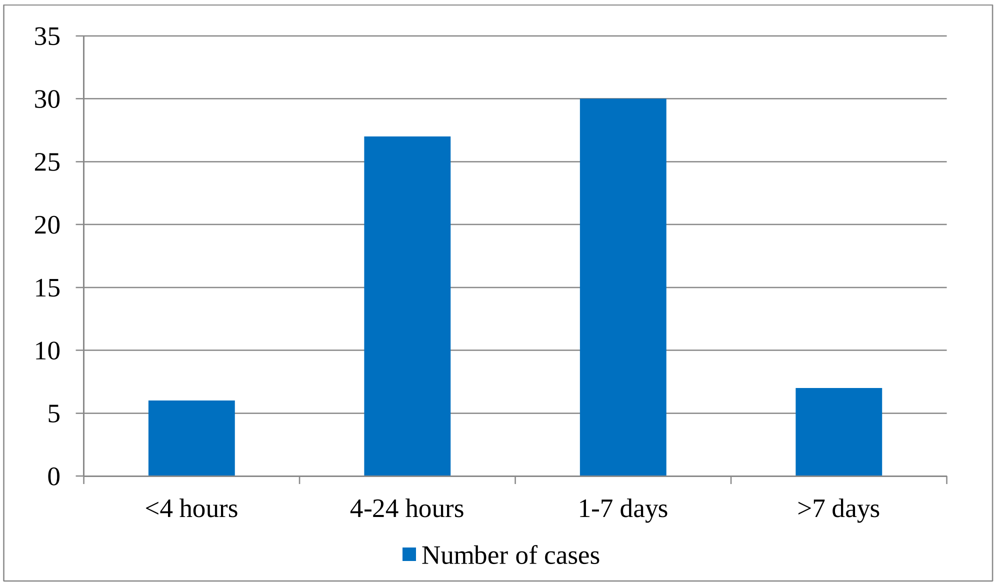


The survival period depends on various factors such as age of the individual, severity of head trauma, associated visceral injuries and timely medical interventions. Out of 70 cases, only 6 cases (8.6%) survived for less than 4 hours, 27 cases (38.6%) survived for 4 to 24 hours. The majority of the cases, i.e. 30 cases (42.8%) survived for 1-7 days whereas 7 cases (10%) survived for more than a week (as shown in Table 6 and Graph 6).

Table 6- Distribution of cases according to survival period

Survival period	Number of cases	Percentage
<4 hours	6	8.6
4-24 hours	27	38.6
1-7 days	30	42.8
>7 days	7	10
Total	70	100

Graph 6- Graphical representation of cases according to survival period

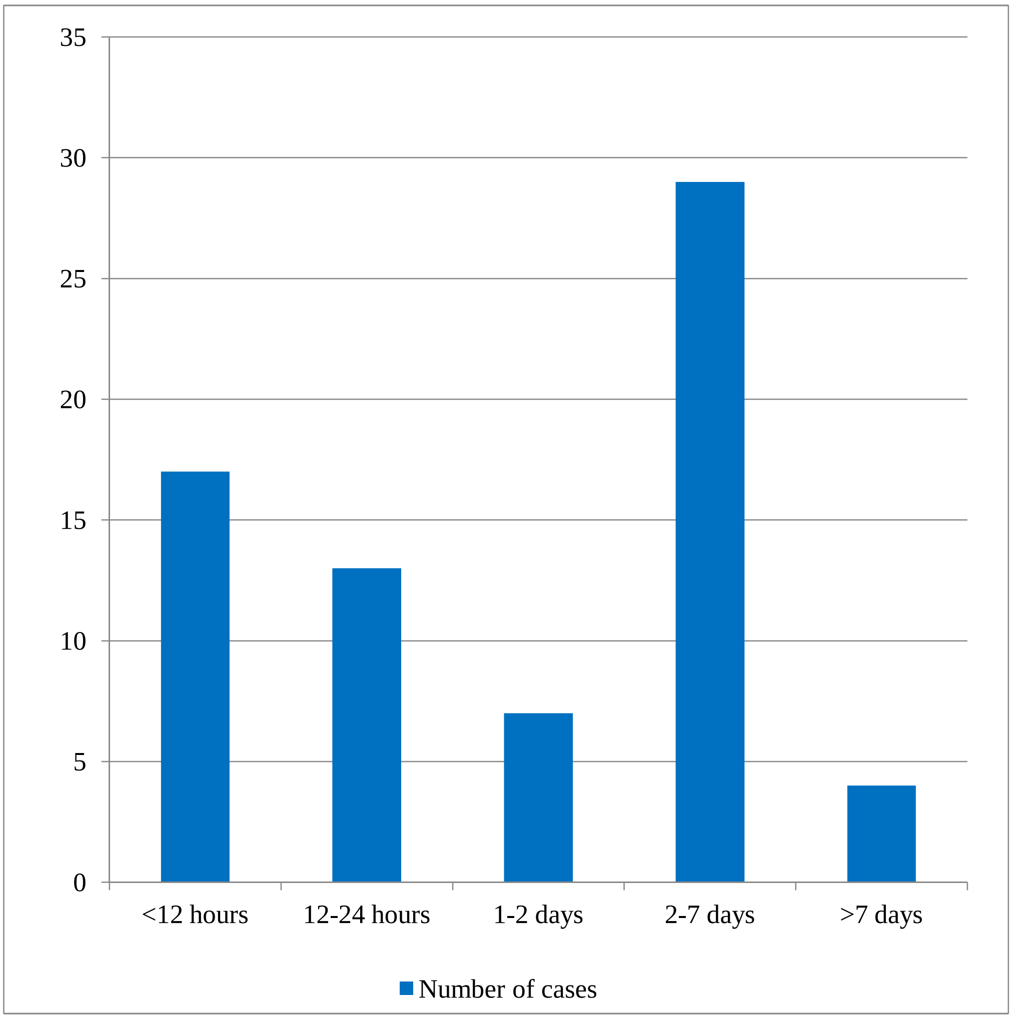


As there may be some patho-physiological changes or healing with time which may bring about a change so the findings by the radiologist and that of autopsy would significantly vary depending upon the survival period, hence there is significant relationship between the CT scan and death. In 17 cases (24.3%), the time interval between CT scan and death was less than 12 hours while this time interval was 12-24 hours in 13 cases (18.6%) as shown in Table 7 and Graph 7.

Table 7- Distribution of cases according to time interval between CT scan and death

Time interval	Number of cases	Percentage
<12 hours	17	24.3
12-24 hours	13	18.6
1-2 days	7	10
2-7 days	29	41.4
>7 days	4	5.7
Total	70	100

<u>Graph 7</u>- Graphical representation of cases according to time interval between CT scan and death



<u>Table 8</u>- Comparison of scalp injury in Autopsy and CT scan

Total number of cases	**Scalp injury at Autopsy**	**Scalp injury at CT scan**
70	64	31

Out of 70 cases, scalp injuries were noted in 64 cases at autopsy whereas CT scan could appreciate it only in 31 cases (as shown in Table 8). This incongruity might be because the scalp injury could have been minimal and less significant as compared to the injury to the skull and its contents and the other underlying reason is that scalp injury is quite more evident to the naked eyes so therefore there is quite a high possibility of under reporting it by the Radiologist.

<u>Table 9</u>- Comparison of Skull fractures in Autopsy and CT scan

Total number of cases	**Detected at Autopsy**	**Detected at CT**
70	47	36

Out of 70 cases, 36 skull fractures were observed in CT scan while 47 cases of skull fractures were noted during autopsy so there is incongruence of 11 cases which were not appreciated by CT scan (as shown in Table 9).

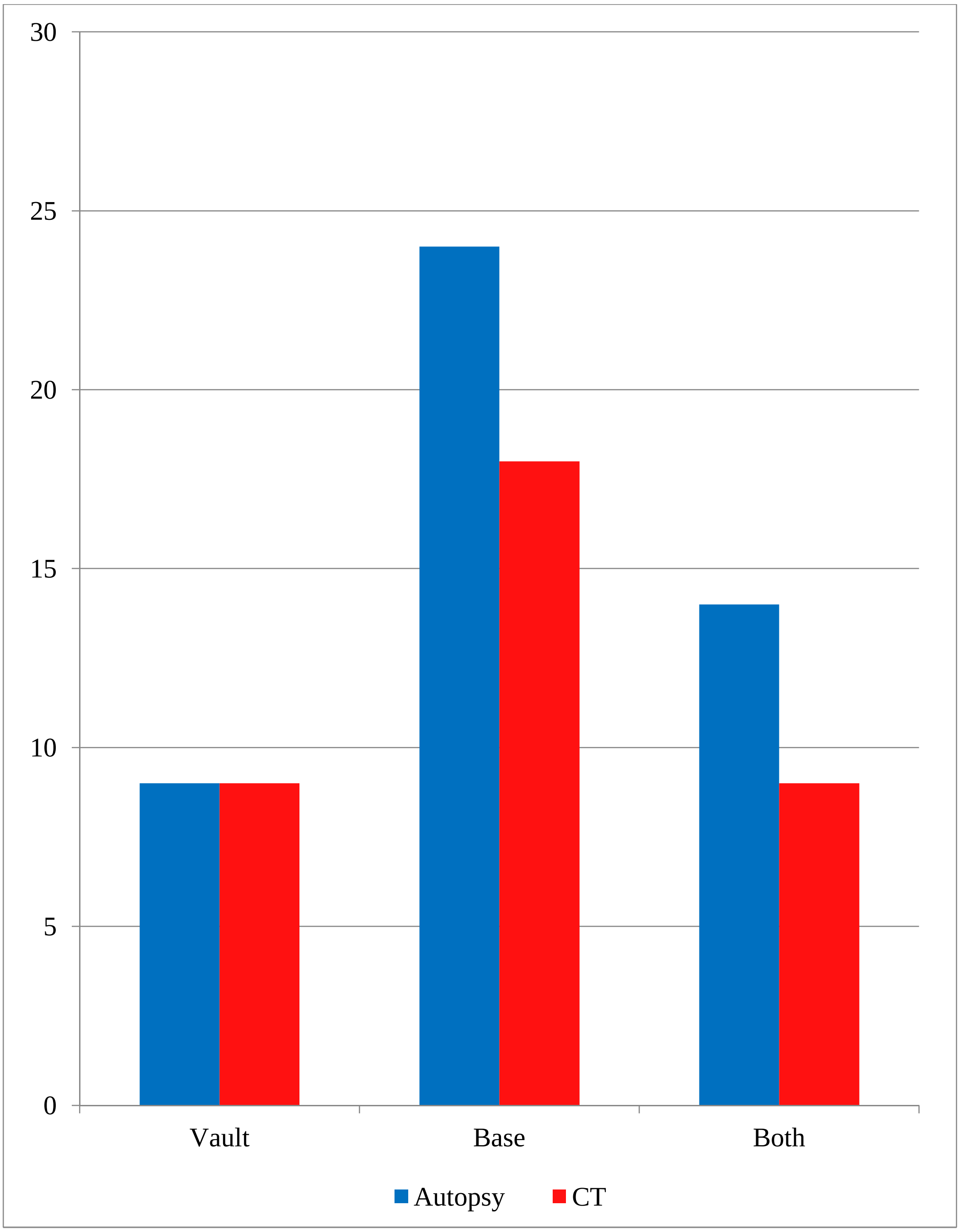
6 cases (54.5%) of exclusive basal fractures were missed and 5 cases (45.5%) involving both base and vault were not picked by the CT scan while all the fractures of the vault of skull were reported by the CT (as shown in Table 10 and Graph 8). This could be because of the various cranial fossae and crevices present at the floor or might be the fracture being too small to have been picked up by the CT scan.

The clinical examination is still more reliable than CT scan in the detection of basilar skull fractures as the CT scan has low sensitivity for basilar skull fractures hence small non-displaced linear skull fractures may be missed.

Table 10- Comparison of Anatomical location of Skull fractures in Autopsy and CT scan

	Autopsy		**CT scan**		**Missed**	
Location	**Number**	**Percentage**	**Number**	**Percentage**	**Number**	**Percentage**
Vault	9	19.1	9	25	0	0
Base	24	51.1	18	50	6	54.5
Both	14	29.8	9	25	5	45.5
Total	47	100	36	100	11	100

<u>Graph 8</u>- Graphical representation of comparison of anatomical location of skull fractures in Autopsy and CT scan

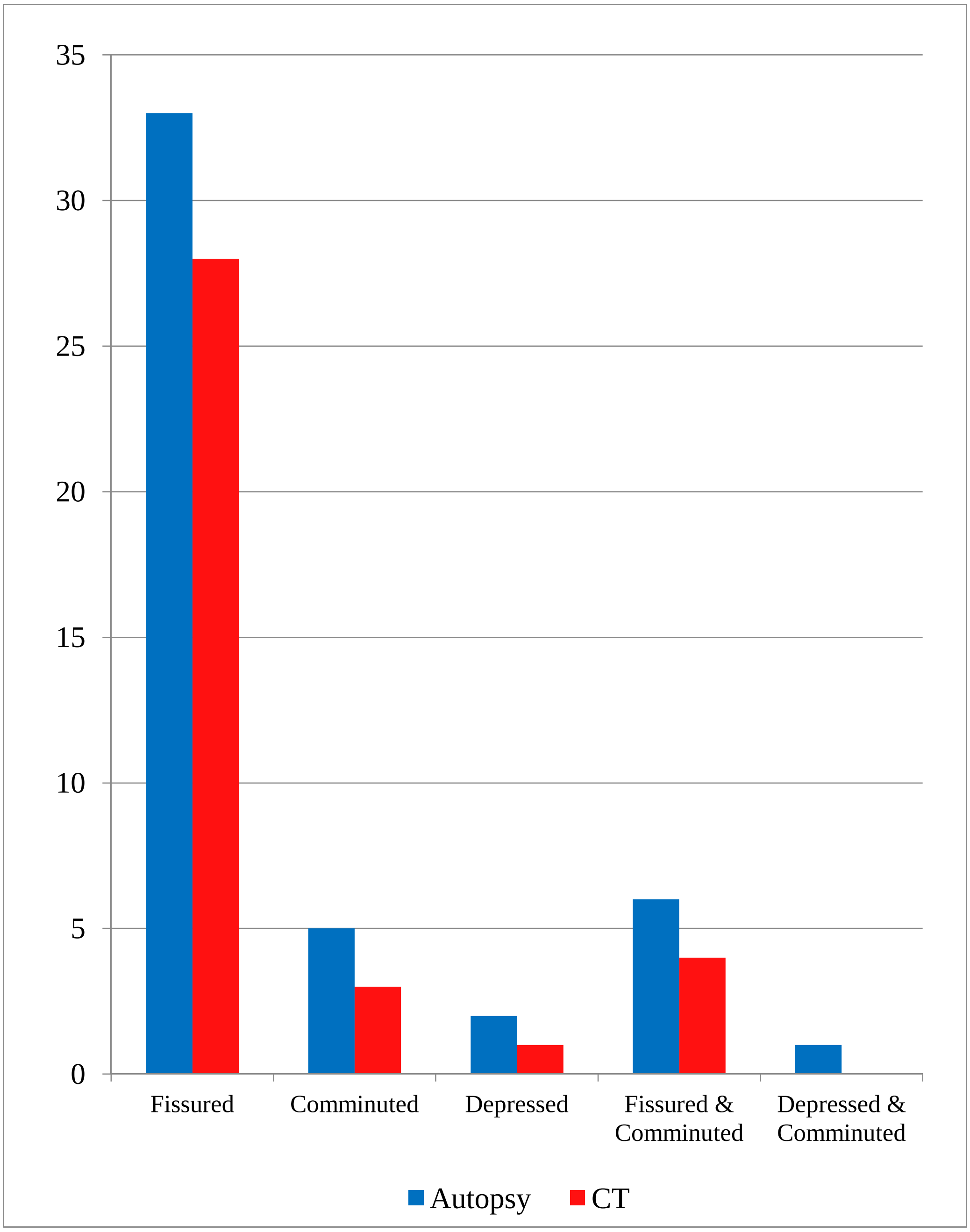


In our study, the fissured fractures came out to be the most common skull fractures. It was reported during autopsy in 33 cases and was not detected by CT scan in 5 cases. CT scan failed to detect 2 cases of comminuted fracture and a case of depressed fracture. Fracture comprising both fissured and comminuted were reported during autopsy in 6 cases but CT scan could pick only in 4 cases so there was incongruence of 2 cases (as shown in Table 11 and Graph 9).

Table 11- Comparison of type of fractures at Autopsy and CT scan

	Autopsy		**CT scan**		**Missed**	
Type	**Number**	**%**	**Number**	**%**	**Number**	**%**
Fissured	33	70.2	28	77.8	5	45.4
Comminuted	5	10.6	3	8.3	2	18.2
Depressed	2	4.3	1	2.8	1	9.1
Fissured & Comminuted	6	12.8	4	11.1	2	18.2
Depressed & Comminuted	1	2.1	0	0	1	9.1
Total	47	100	36	100	11	100

<u>Graph 9</u>- Graphical representation of types of fractures at Autopsy and CT scan

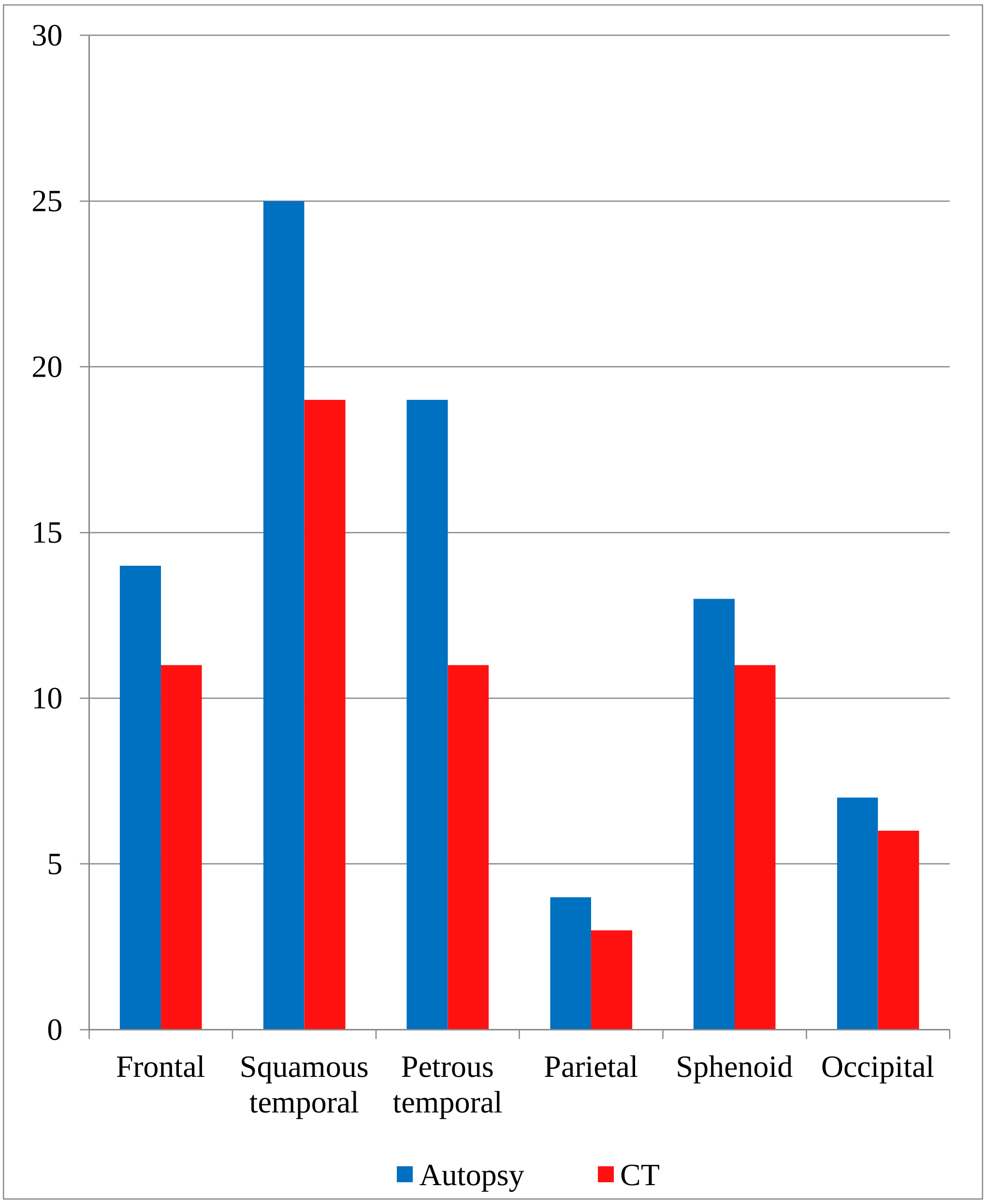


The most common site for fracture of skull was squamous temporal followed by petrous temporal. 6 cases of squamous temporal and 8 cases of petrous temporal fractures were not detected by CT scan. 11 cases of frontal bone fracture were detected by CT scan while autopsy reported it in 14 cases. On the other hand 13 cases of sphenoid bone fracture were observed during autopsy but only 11 cases were picked by CT scan (as shown in Table 12 and Graph 10).

Table 12- Comparison of Bone involvement in fractures

	Autopsy	**CT**	**Missed**	
Bone	**Number**	**Number**	**Number**	**Percentage**
Frontal	14	11	3	21.4
Squamous temporal	25	19	6	24
Petrous temporal	19	11	8	42.1
Parietal	4	3	1	25
Sphenoid	13	11	2	15.3
Occipital	7	6	1	14.3

<u>Graph 10</u>- Graphical representation of comparison of bone involvement in fractures

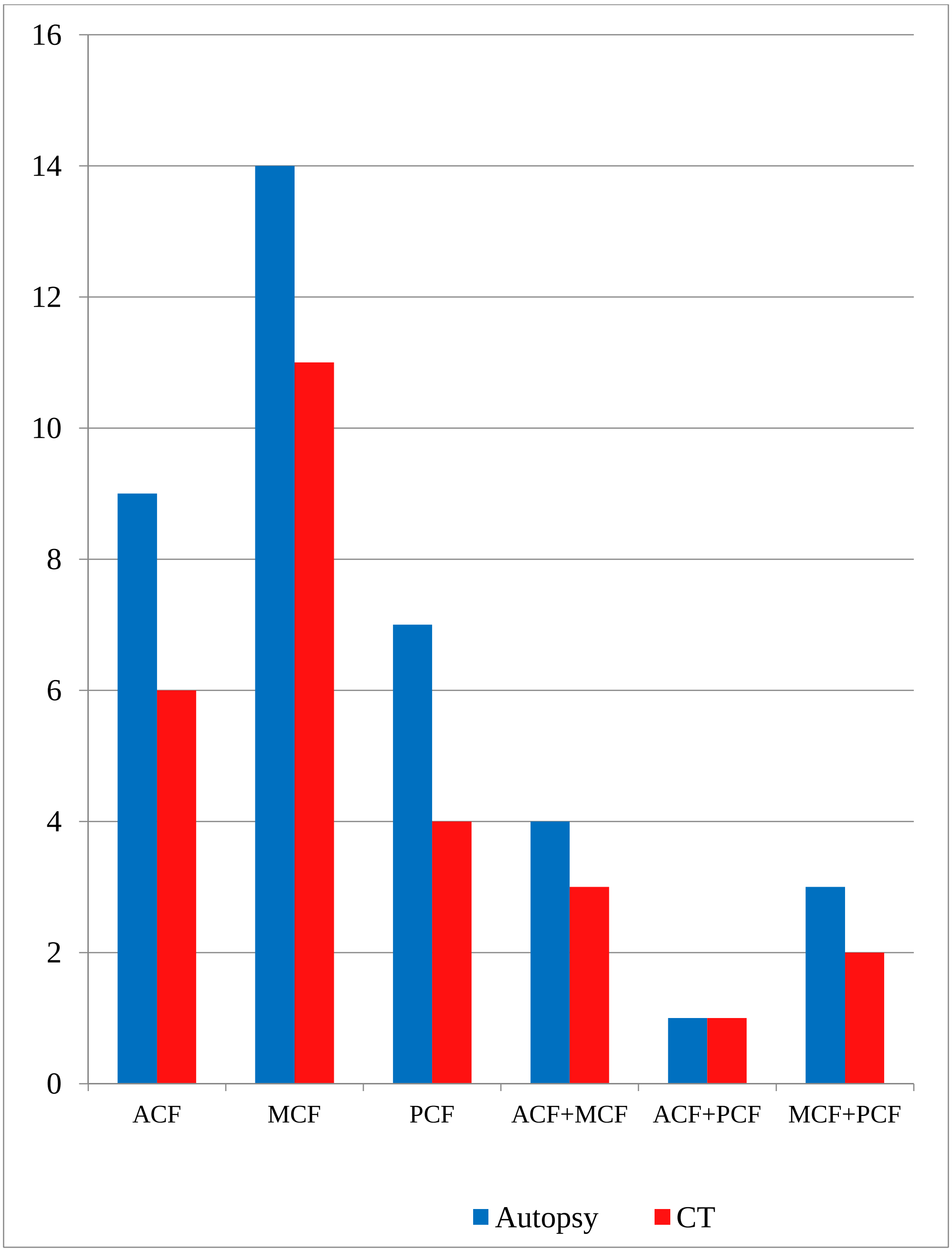


The most common basal fracture was middle cranial fossa fracture which was reported in 14 cases during autopsy while CT scan could detect only in 11 cases so there was disparity of 3 cases. CT scan missed 3 cases each of anterior cranial fossa and posterior cranial fossa fractures while a case each involving both ACF and MCF, and MCF and PCF (as shown in Table 13 and Graph 11).

Table 13- Comparison of fossa involved in basal fracture

	Autopsy		**CT scan**		**Missed**	
Fossae	**Number**	**%**	**Number**	**%**	**Number**	**%**
ACF	9	23.7	6	22.2	3	27.3
MCF	14	36.9	11	40.8	3	27.3
PCF	7	18.4	4	14.8	3	27.3
ACF+MCF	4	10.5	3	11.1	1	9.1
ACF+PCF	1	2.6	1	3.7	0	0
MCF+PCF	3	7.9	2	7.4	1	9.1
Total	38	100	27	100	11	100

<u>Graph 11</u>- Graphical representation of comparison of fossa involved in basal fractures

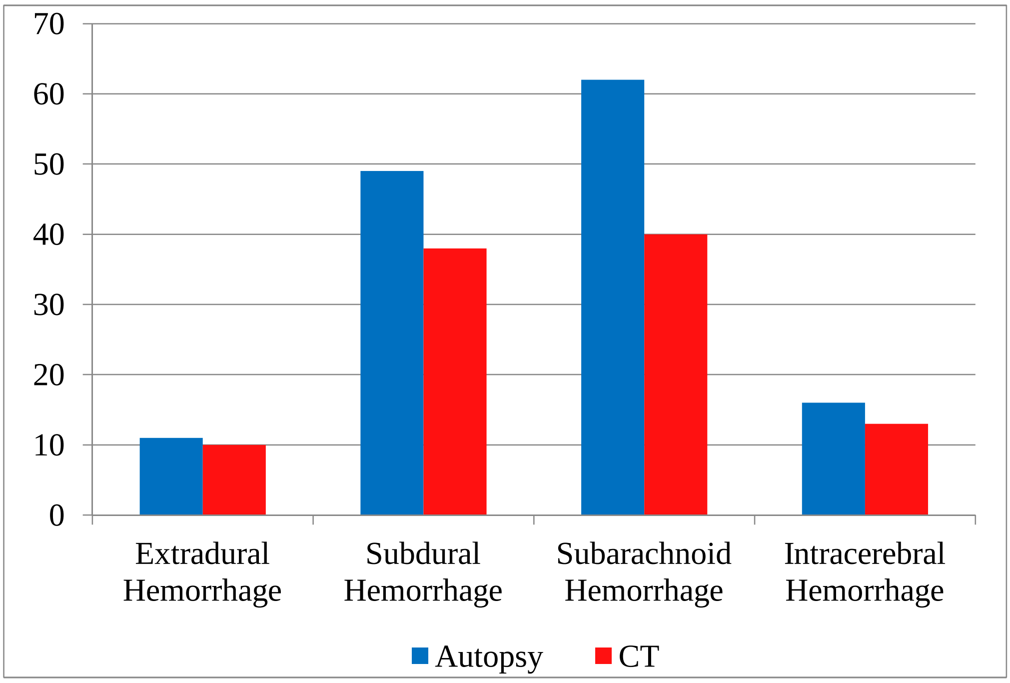


In our study the most common intracranial hemorrhage came out to be subarachnoid hemorrhage which was missed by CT scan in 22 cases (35.5%) followed by subdural hemorrhage 11 cases (22.4%). A case of extradural hemorrhage (9%) and 3 cases of intracerebral hemorrhage (18.8%) were also remained undetected by CT scan (as shown in Table 14 and Graph 12).

Table 14- Comparison of Intracranial hemorrhage

Intracranial Hemorrhage	Autopsy	CT	Missed
Extradural Hemorrhage	11	10	1 (9%)
Subdural Hemorrhage	49	38	11 (22.4%)
Subarachnoid Hemorrhage	62	40	22 (35.5%)
Intracerebral Hemorrhage	16	13	3 (18.8%)

Graph 12- Graphical representation of comparison of Intracranial hemorrhages

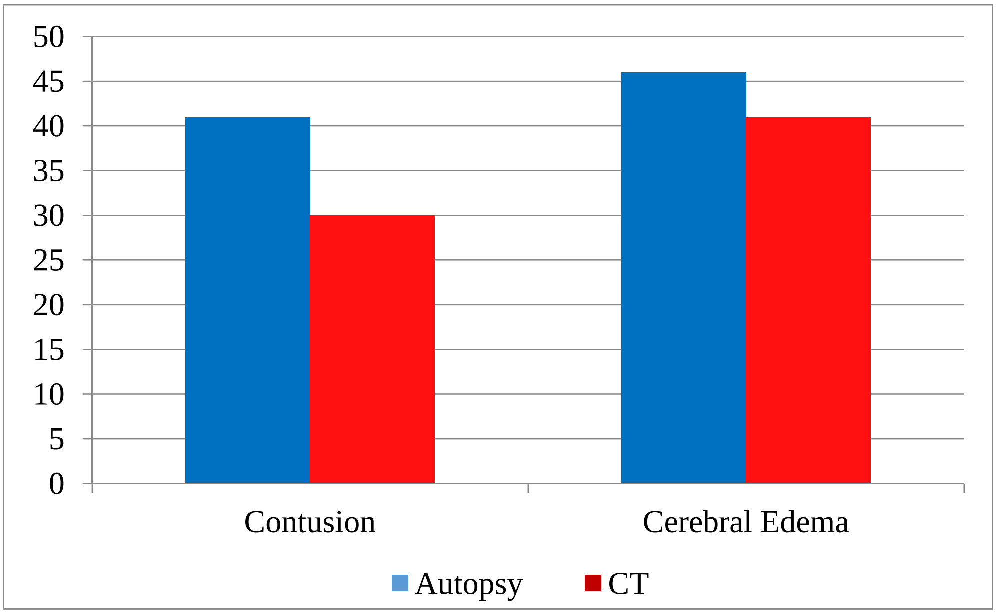


There was disparity in 11 cases of brain contusion as it was observed in 41 cases during autopsy while CT scan could pick only 30 cases. In 46 cases, cerebral edema was noted in autopsy while it was reported by CT scan in only 41 cases so in 5 cases it was missed by CT scan (as shown in Table 15 and Graph 13).

Table 15- Comparison of traumatic brain injury noted in Autopsy and CT scan

Traumatic Brain Injury	Autopsy	CT	Missed
Contusion	41	30	11 (26.8%)
Laceration	0	0	0
Cerebral Edema	46	41	5 (10.9%)

Graph 13- Graphical representation of comparison of traumatic brain injury



DISCUSSION

The present study titled "Correlation of Computed Tomography scan findings with Autopsy findings in fatal head injury cases- A one and half year Hospital based cross sectional study" was conducted on fatal head injury cases who were hospitalized and CT scan of head was done and were subjected for postmortem examination. A total of 70 cases fulfilled the criteria.

The most vulnerable age group in our study was 19-29 years and 40-49 years followed by 30-39 years which is similar to the studies conducted by Ravikumar et al[34], Menon et al[35] and Kiran et al.[36] The accidents are more common in this age group due to denial of traffic rules and over speeding. On contrary Pathak et al[37] and Katageri et al[38]found out the principal age group to be 31-40 years.

Out of 70 cases, 56 were males (80%) and 14 were females (20%). The male to female ratio was 4:1. This is similar to the studies conducted by Singh A et al[39], Nilambar et al[40] and Singh R et al.[41] where they concluded that male outnumbered female victims. This can be due to greater exposure of males on streets and participation in high risk activities such as recklessness driving, over speeding and drunken driving.

In this study, the most common cause of acute head trauma was road traffic accidents (63 cases, 90%) followed by fall from height (7 cases, 10%). Many other studies have also reported road traffic accident as the leading cause of traumatic brain injury such as studies conducted by Borkar et al[42], Singh AK et al[43], Parchani et al[44], Saxena et al[45] and Sahu et al.[46] According to Sahu et al 64% of the cases were of road traffic accidents while 20% were of fall from height.

Rural and semi-urban inhabitants constituted the majority of victims in the present study, i.e. 40 (57.2%) as compared to the victims from urban background, i.e. 30 (42.8%) which is similar to the studies conducted by Reddy et al[47] and Singh Y et al.[48] According to Reddy et al 82% victims hailed from rural or semi-urban background while 15% were from urban background. According to Singh Y et al 57% were rural and semi-urban residents while 43% were urban inhabitants. This can be attributed to the reason that the greater proportion of victims in road traffic accidents are of low education status and it may be correlated with ignorance of road safety rules and traffic sense.

Among the victims of road traffic accidents, the maximum number of accidents were seen among the 2-wheeler riders which accounts to 37 cases (52.9%) followed by pillion riders (14 cases, 20%). This is in correlation with the study conducted by Gupta et al[49] where riders were 892 (70.96%) and pillion riders were 364 (28.95%). This could be because of lack of safety measures like wearing helmets. In our study, other than 2-wheeler riders and pillion riders, 11 victims were pedestrians (15.7%) while 1 case was of 4-wheeler rider. This can be correlated to the studies conducted by Honnungar et al[50] and Menon et al.[51]

According to this study in 38 cases (54.3%), head injury was suspected and CT scan was done in 1-4 hours of the incidence while in 12 cases (17.1%) the CT scan was done in 4-8 hours and in 16 cases it was done in 8-24 hours. Similar observations were made by Equabal et al[52] where 76% of the cases were scanned within 8 hours of injury while remaining were taken up for computerized tomography thereafter.

The survival period depends on various factors such as age of the individual, severity of head trauma, associated visceral injuries and timely medical interventions. Out of 70 cases, only 6 cases (8.6%) survived for less than 4 hours, 27 cases (38.6%) survived for 4 to 24 hours. The majority of the cases, i.e. 30 cases (42.8%) survived for 1-7 days whereas 7 cases (10%) survived for more than a week. This can be correlated to the study conducted by Reddy et al[47] in which 26% individuals survived for 2-24 hours while 12% survived for 2-6 days.

In the present study out of 70 cases, 36 skull fractures were appreciated by CT scan while 47 cases of skull fractures were reported during autopsy so there is incongruence of 11 cases which remained undetected by CT scan. According to Sharma et al[10], 76.3% of skull fractures were diagnosed in both CT scan and Autopsy whereas 23.7% of them remained undiagnosed by CT scan. Kumar et al[53] observed that 69.63% cases of head injury had skull fracture. In another study of Reddy S et al[8] 48% of the cases of skull fracture were observed during autopsy while 38% cases were detected by CT scan.

The vault of skull alone was fractured in 9 cases (19.1%), base of the skull alone was fractured in 24 cases (51.1%) and both vault and base were involved in 14 cases (29.8%) in this study which is similar to the studies conducted by Gopal et al.[54]In this study 6 cases (54.5%) of exclusive basal fractures were missed and 5 cases (45.5%) involving both base and vault were not picked by the CT scan while all the fractures of the vault of skull were reported by the CT. Similar observation was made in the studies conducted by Pathak et al[16] in which both vault and basal fractures are likely to be missed when they are undisplaced and even a bone window image would be unable to detect them.

In this study, the fissured fractures came out to be the most common skull fractures. It was reported during autopsy in 33 cases and was not picked by CT scan in 5 cases. CT scan failed to detect 2 cases of comminuted fracture and a case of depressed fracture. Fracture comprising both fissured and comminuted were reported during autopsy in 6 cases but CT scan could pick only in 4 cases so there was incongruence of 2 cases. A study done by Manish et al[55] showed that linear fracture (38.8%) was the commonest fracture followed by comminuted fracture (27.7%) and depressed fracture (11.1%) which is consistent with the present study. Goyal et al[9] in their study have observed that 77 cases (65%) had linear fracture and 13 cases (11%) had depressed fractures whereas CT scan was able to pick 65 cases (55%) and 19 cases (16%) respectively.

Squamous temporal is the most common site for skull fracture followed by petrous temporal. 6 cases of squamous temporal and 8 cases of petrous temporal fractures were not appreciated by CT scan. 11 cases of frontal bone fracture were detected by CT scan while autopsy reported it in 14 cases. On the other hand 13 cases of sphenoid bone fracture were observed during autopsy but CT scan could pick only in 11 cases. Jacobsen et al[21] observed that lesser wing sphenoid fractures were not detected in all 5 cases, greater wing fractures were not detected in 10 of 15 cases and petrous temporal bone fractures were not detected in 9 of 15 cases.

The most common basal fracture was middle cranial fossa fracture which was reported in 14 cases during autopsy while CT scan could detect only in 11 cases so there was disparity of 3 cases. CT scan missed 3 cases each of anterior cranial fossa and posterior cranial fossa fractures while a case each involving both ACF and MCF, and MCF and PCF which is in consistent with the study conducted by Reddy et al[8] where they observed that the commonest region of the base of skull involved in fracture was middle cranial fossa (52%) followed by anterior cranial fossa (28%) and posterior cranial fossa (20%). The autopsy findings of their study were in concurrence with the findings of CT scan in 38% of cases.

In this study, subarachnoid hemorrhage came out to be the most common intracranial hemorrhage which was missed by CT scan in 22 cases (35.5%) followed by subdural hemorrhage 11 cases (22.4%). A case of extradural hemorrhage (9%) and 3 cases of intracerebral hemorrhage (18.8%) were also remained undetected by CT scan. Sharma et al[10] in their study observed that amongst extradural hemorrhage 66.7% were detected in both CT scan and autopsy while CT failed to detect in 33.3% cases. Subdural hemorrhages were observed in both CT scan and autopsy and no mismatch was seen. Among subarachnoid hemorrhage, 64.3% were reported in both CT scan and autopsy while 35.7% of them remained unreported by CT scan. 70% of intracerebral hemorrhages were reported in both CT scan and autopsy while 30% remained undetected by CT scan.

In this study, in brain contusion there was disparity of 11 cases as it was observed in 41 cases during autopsy while CT scan could pick only in 30 cases. In 46 cases, cerebral edema was reported in autopsy while it was appreciated by CT scan in only 41 cases so CT scan failed to detect in 5 cases. Pathak et al[16] in their study observed that autopsy revealed contusion in temporal region in 26, frontal region in 16, occipital region in 5 and in cerebellum in 2 patients. However CT scan was able to detect the same in 16 cases in temporal and 10 cases in the frontal region. In a patient, CT scan over diagnosed a parietal contusion which was not evident at autopsy. Autopsy of the brain stem revealed contusion in 30 patients however only 6 patients could show the same on CT scan.

CONCLUSION

In the present study, out of 172 cases of head injury 70 cases were hospitalized, CT scan of head was done and were subjected to postmortem examination and hence these 70 cases are included in this study. The most vulnerable age group for head injury was 19-29 years. 56 (80%) were males as compared to 14 (20%) females. The most common cause of acute head trauma came out to be road traffic accidents (90%) followed by fall from height (10%). 40 cases (57.2%) were from rural background whereas 30 cases (42.8%) were from urban background. Among 63 cases of road traffic accidents, 37 cases (52.9%) were 2-wheeler riders followed by 14 cases (20%) of pillion riders while 11 (15.7%) were pedestrians.

In more than half of the cases (57.2%) the head injury was suspected and CT scan was done within 4 hours of the suspected trauma to the head. In 30 cases (42.8%) survival period was 1-7 days while in 7 cases (10%) the survival period was more than a week. In 17 cases (24.3%) the patient died in less than 12 hours after doing a CT scan while in 29 cases (41.4%) they died in 2-7 days. Out of 70 cases, scalp injury was observed in 64 cases in postmortem examination but CT scan could pick scalp injury in only 31 cases so there is incongruence of 33 cases in scalp injury.

Among 70 cases, skull fractures were reported in 47 cases at autopsy while CT scan could detect only 36 cases so there was disparity of 11 cases in skull fractures. 6 cases (54.5%) of exclusive basal fractures were missed alongwith 5 cases (45.5%) involving both base and vault by CT scan. The most common type of skull fractures missed by CT scan were solitary fissured fractures (5 cases) followed by 2 cases of comminuted fractures and a case of depressed fracture.

8 cases of fracture of the petrous part of temporal bone were missed alongwith 6 cases of squamous temporal bone and 3 cases of frontal bone. Anterior cranial fossa, Middle cranial fossa and Posterior cranial fossa fractures were missed in 3 cases each in CT scan as compared to Autopsy. Among the intracranial hemorrhages, subarachnoid hemorrhage was undetected in 22 cases, subdural hemorrhage was undetected in 11 cases, and extradural hemorrhage was undetected in 1 case while intracerebral hemorrhage was undetected in 3 cases. Contusions were missed in 11 cases (26.8%) by CT scan. The inferior aspects of frontal and temporal lobes are the most common areas where contusions were missed. Cerebral edema was not detected in 5 cases (10.9%).

Through this study we could conclude that there are quite a few shortcomings in the outcome of head injury patients which other authors also highlighted in their studies. The CT scan has low sensitivity and accuracy for detecting the traumatic injuries. CT scans are inadequate for courtroom testimony but they provide great help to the clinicians in the emergency conditions. If the evidence of trauma is based solely on CT scan reports, there is a high possibility of erroneous accusations and convictions.

Autopsy being a direct visual examination of the lesions can detect more pathological findings compared to CT scan which is a virtual interpretation of intracranial lesions. The skull fractures are readily identified on the bone windows of CT scan but small non-displaced linear skull fractures may be missed on CT scan so the clinical examination is still more reliable than CT scan in detection of basilar skull fractures. CT scan obtained too early may not detect small epidural hematomas which could later expand and can cause secondary brain injury. Non-hemorrhagic contusions are often not visualized on initial CT scan but could show mild edema or hemorrhagic conversion over 24-48 hours. The probable reasons for disparity observed on CT examination are-

(1) Mass effect of the various types of intracranial lesions is not developed in initial stages of acute head trauma and hence the CT scan is most likely fails to detect the exact anatomical location of the lesion.

(2) The appearance of the various intracranial injuries on CT scanning depends upon the globin content of the extravasated haemoglobin.

(3) Beam hardening artifact and partial volume effect

Virtopsy or virtual autopsy is a recent advance in the field of forensic investigation to know the cause of death but it has various limitations over the conventional autopsy such as small tissue injury could be missed in virtopsy and it cannot give the infection status. So, virtopsy is a useful tool but it cannot replace the conventional autopsy.

SUMMARY

- A study titled "Correlation of Computed Tomography scan findings with Autopsy findings in fatal head injury cases- A one and half year Hospital based cross sectional study" was conducted on fatal head injury cases who were hospitalized and CT scan of head was done and were subjected for postmortem examination in Department of Forensic Medicine and Toxicology, Jawaharlal Nehru Medical College, Belagavi from January 2017 to July 2018 over a period of 19 months.
- All fatal head injury cases subjected for postmortem examination where antemortem CT scan reports were available were taken up for the study. A detailed dissection and examination of the head of each case was done as per the standard autopsy procedure and the various types of injuries to the scalp, skull bones, hemorrhages and traumatic injuries to the brain were recorded and photographed.
- The CT scan reports of the deceased were collected from the Radio diagnosis department and discussed with the Radiologist. Further a comparative evaluation of postmortem findings of the head injuries with that of the CT scan was done.
- Out of 172 cases of head injury 70 cases were hospitalized, CT scan of head was done and were subjected to postmortem examination and hence these 70 cases are included in this study. The most vulnerable age group for head injury was 19-29 years. 56 (80%) were males as compared to 14 (20%) females.
- The most common cause of acute head trauma came out to be road traffic accidents (90%) followed by fall from height (10%). 40 cases (57.2%) were

from rural background whereas 30 cases (42.8%) were from urban background. Among 63 cases of road traffic accidents, 37 cases (52.9%) were 2-wheeler riders followed by 14 cases (20%) of pillion riders while 11 (15.7%) were pedestrians.

- Among 70 cases, skull fractures were reported in 47 cases at autopsy while CT scan could detect only 36 cases so there was disparity of 11 cases in skull fractures. 6 cases (54.5%) of exclusive basal fractures were missed alongwith 5 cases (45.5%) involving both base and vault by CT scan. The most common type of skull fractures missed by CT scan were solitary fissured fractures (5 cases) followed by 2 cases of comminuted fractures and a case of depressed fracture.
- 8 cases of fracture of the petrous part of temporal bone were missed alongwith 6 cases of squamous temporal bone and 3 cases of frontal bone. Anterior cranial fossa, Middle cranial fossa and Posterior cranial fossa fractures were missed in 3 cases each in CT scan as compared to Autopsy. Among the intracranial hemorrhages, subarachnoid hemorrhage was undetected in 22 cases, subdural hemorrhage was undetected in 11 cases, and extradural hemorrhage was undetected in 1 case while intracerebral hemorrhage was undetected in 3 cases. Contusions were missed in 11 cases (26.8%) by CT scan. The inferior aspects of frontal and temporal lobes are the most common areas where contusions were missed. Cerebral edema was not detected in 5 cases (10.9%).
- Thus this study emphasizes that autopsy is the gold standard in observing the various intracranial lesions and the virtual autopsy or virtopsy (CT scan and

other imaging techniques) can be a adjuvant only which cannot replace the conventional autopsy.

SCOPE FOR FURTHER STUDY

- A study could be conducted where a Neurosurgeon, Radiologist and a Forensic expert are involved at each level and thorough correlation between clinical, radiological and postmortem findings could be done.

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ANNEXURE I

ETHICAL CLEARANCE

K.L.E.UNIVERSITY'S

JAWAHARLAL NEHRU MEDICAL COLLEGE,

NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)

(Accredited 'A' Grade by NAAC)

Website: http//www.jnmc.edu
E-Mail : dome@jnmc.edu

Phone: (+ 91-(0)831 Office : 2471350
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref: MDC/DOME/ 44

Date: 17/10/2016

To,

J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"CORRELATION OF COMPUTED TOMOGRAPHY SCAN FINDINGS WITH AUTOPSY FINDINGS IN FATAL HEAD INJURY CASES-A ONE YEAR HOSPITAL BASED CROSS SECTIONAL STUDY",** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Arathi Darshan)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

(Dr. Ganga Pilli)
Chairman,
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

ANNEXURE II

INFORMED CONSENT

"CORRELATION OF COMPUTED TOMOGRAPHY SCAN FINDINGS WITH AUTOPSY FINDINGS IN FATAL HEAD INJURY CASES- A ONE AND HALF YEAR HOSPITAL BASED CROSS SECTIONAL STUDY "

Investigators:

Introduction:

You have been invited to give consent for your relative for this study that is to correlate Computed Tomography scan findings with Autopsy findings at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi.

Explanation of procedure:

In the present study you will be asked some questions regarding brief history of patient, details of the injuries, causative agents and circumstances. Patient's Computed Tomography scan report will be used. It takes about 5 to 10 minutes. After collecting the information results will be analyzed.

Possible benefits:

The investigator does not promise or guarantee that you will get direct benefit being in this study. It will benefit the whole community because by this study we will know or identify the lesions caused by head injury which are most likely to be missed or may remain undetected by Computed Tomography scan examination but are appreciated at Autopsy.

Confidentiality:

Your relative's identity will not be revealed. All information will be collected and coded so that no one will know your identity.

Withdrawal:

Participation in this study is voluntary. If you don't wish to participate in this study, you will not lose benefits to which you are entitled.

Cost of participation:

The cost of the study will be borne by the researcher. There will be no additional cost to you for taking part in this study.

Payment of participation:

No incentive will be paid to you for participating in this study.

Risks involved in the study to the participants:

This study does not contain any intervention or major procedures, hence has no adverse effects on the participants. However, if you have any questions about this study, you can contact

If you have any queries about your rights as a study subject, you may contact Dr. G.S. Pilli, J.N. Medical College, Institutional Ethical Committee for Human Subjects Research, at J.N. Medical College, Belagavi. Ph. no 94 0275601.

Legal rights:

By signing this consent form, you are not waiving any of your legal rights.

Publication rights:

The results of the survey will be used for teaching and medical publications. However the participant's identity will be kept confidential.

CONSENT FORM

"CORRELATION OF COMPUTED TOMOGRAPHY SCAN FINDINGS WITH AUTOPSY FINDINGS IN FATAL HEAD INJURY CASES- A ONE AND HALF YEAR HOSPITAL BASED CROSS SECTIONAL STUDY "

I volunteer and give consent for the participation of my relative and/or my child in this study. I have read the consent or it has been read to me. The study has been fully explained to me in my own vernacular language and I was given sufficient time to clarify my doubts.

Participant name: ___________________ Participant sign/thumb print: _______________

Investigator's name: Investigator's sign:________________

Witness´s name:_________________________ Witness's sign:_______________

Place:______________ Date:_________________

ANNEXURE III

PROFORMA FOR STUDY OF HEAD INJURY CASES

"CORRELATION OF COMPUTED TOMOGRAPHY SCAN FINDINGS WITH AUTOPSY FINDINGS IN FATAL HEAD INJURY CASES- A ONE AND HALF YEAR HOSPITAL BASED CROSS SECTIONAL STUDY"

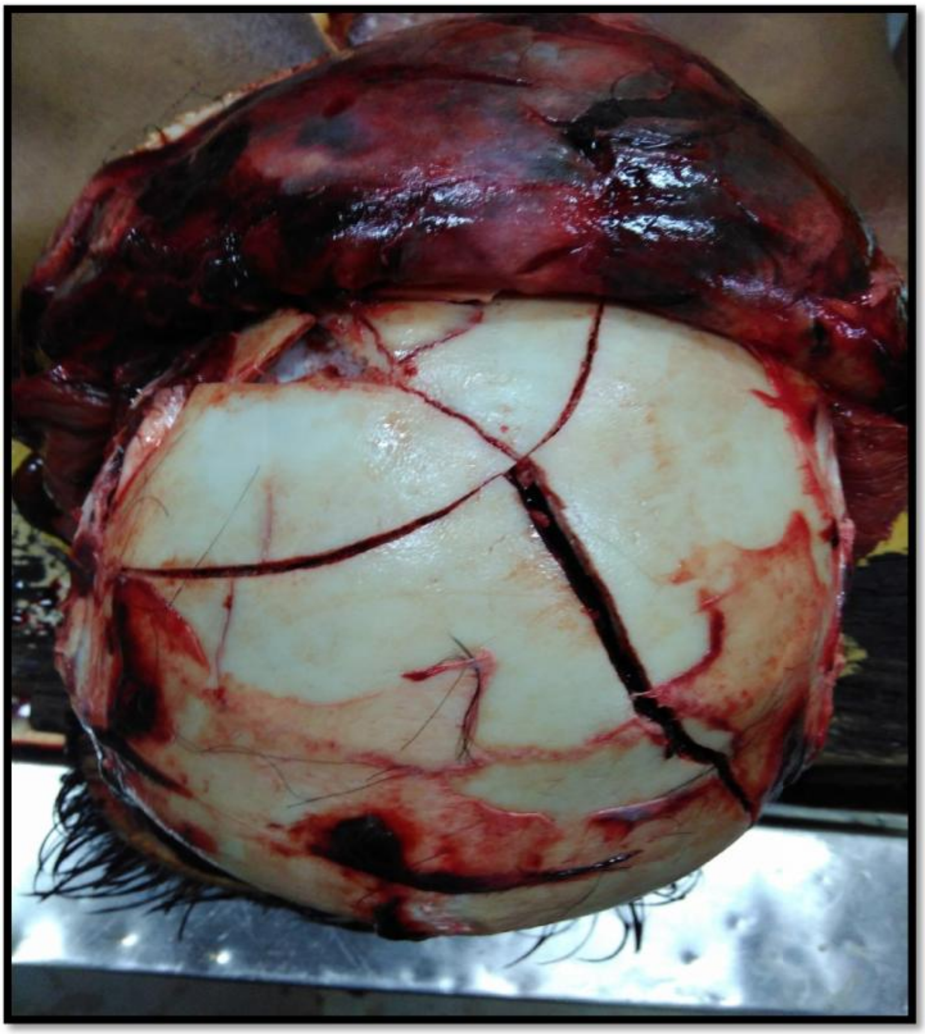
1. **S. No.-**
2. **Name-**
3. **Age-**
4. **Sex-**
5. **OP/ IP No.-**
6. **Address-**
7. **Date and Time of incidence-**
8. **Date and Time of Hospital Admission-**
9. **Brief History of Patient-**
10. **Examination with GCS-**
11. **Comparison between CT scan and Autopsy findings-**

CT scan Findings	Autopsy Findings
CT no. and date- Scalp- Skull vault- Meninges- Brain-	PM no. and date- Scalp- Skull vault- Meninges- Brain-

ANNEXURE - IV

PHOTOGRAPHS

Photograph 1- Diffuse Extravasation of blood in the scalp with comminuted fracture over the vault



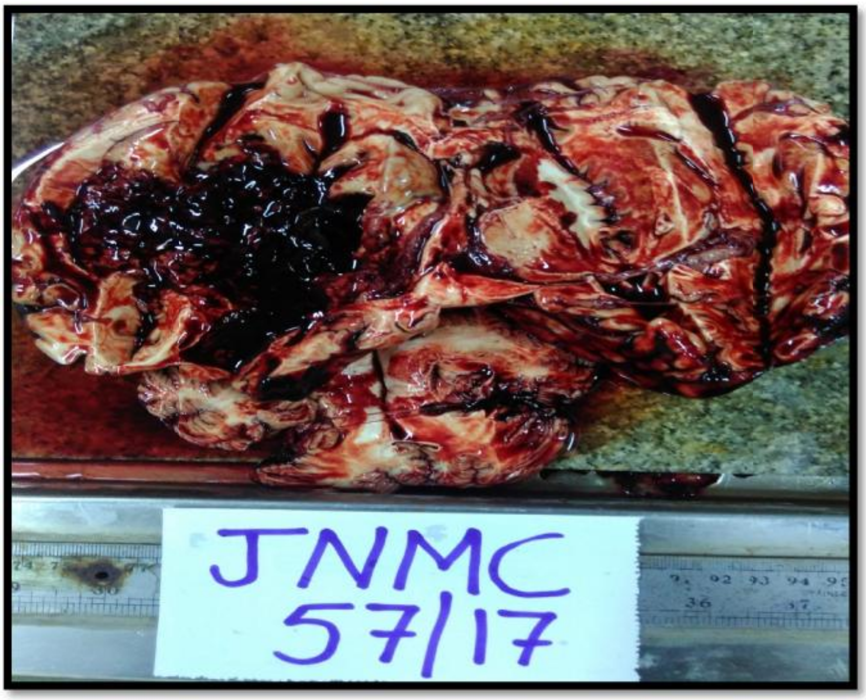
<u>Photograph 2</u>- Comminuted fracture over base of skull involving posterior cranial fossa

<u>Photograph 3</u>- Extradural Hemorrhage present over the right parietal region

Photograph 4- Subdural Hemorrhage

Photograph 5- Diffuse Subarachnoid Hemorrhage

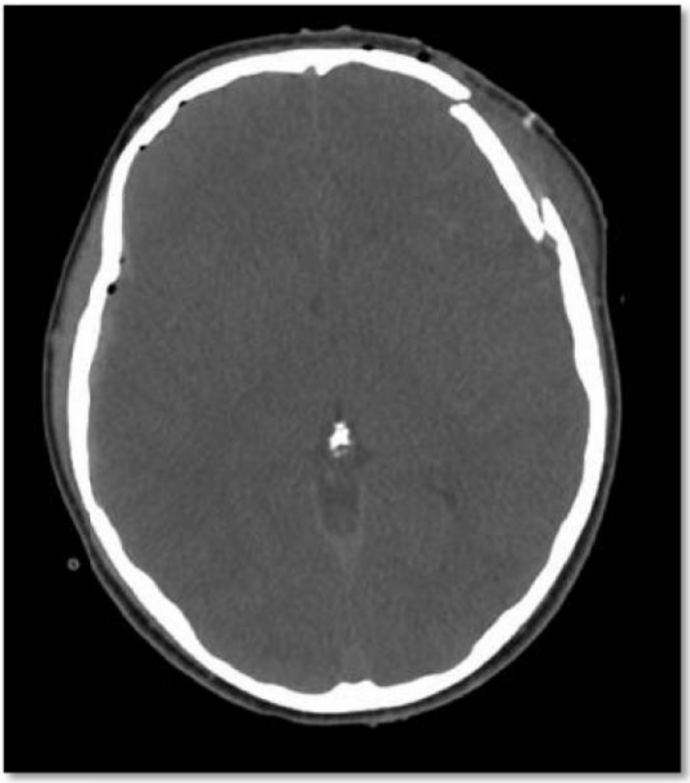
<u>Photograph 6</u>- Intracerebral Hemorrhage



<u>Photograph 7</u>- Sutural Fracture over Skull vault

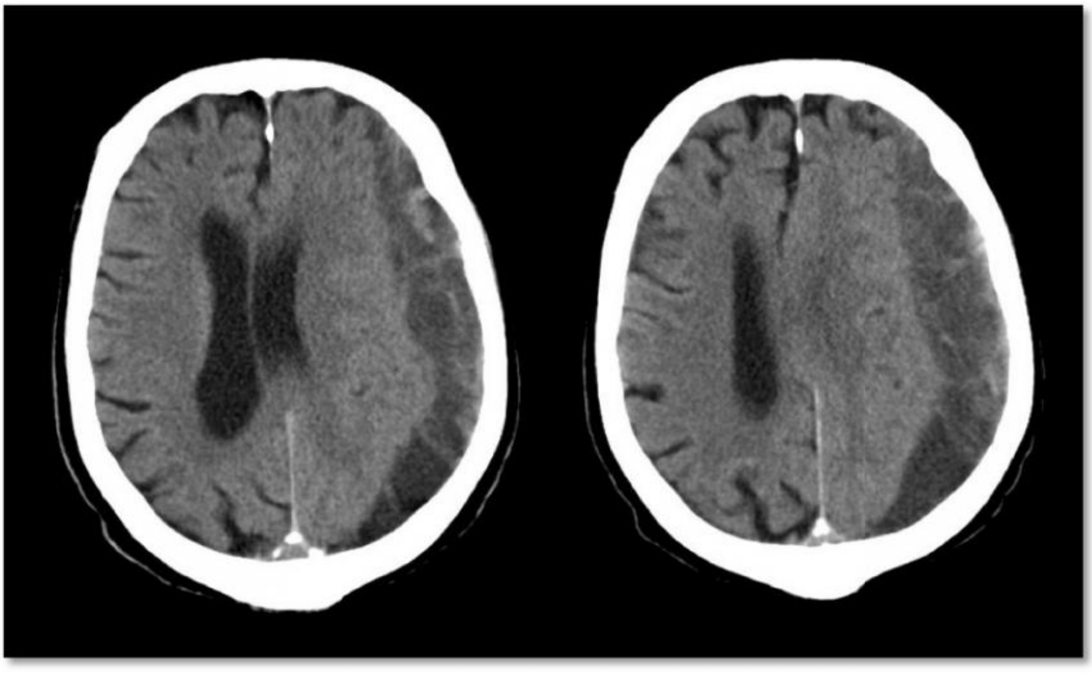
<u>Photograph 8</u>- Cerebral Edema

<u>Photograph 9</u>- CT scan image depicting skull fracture

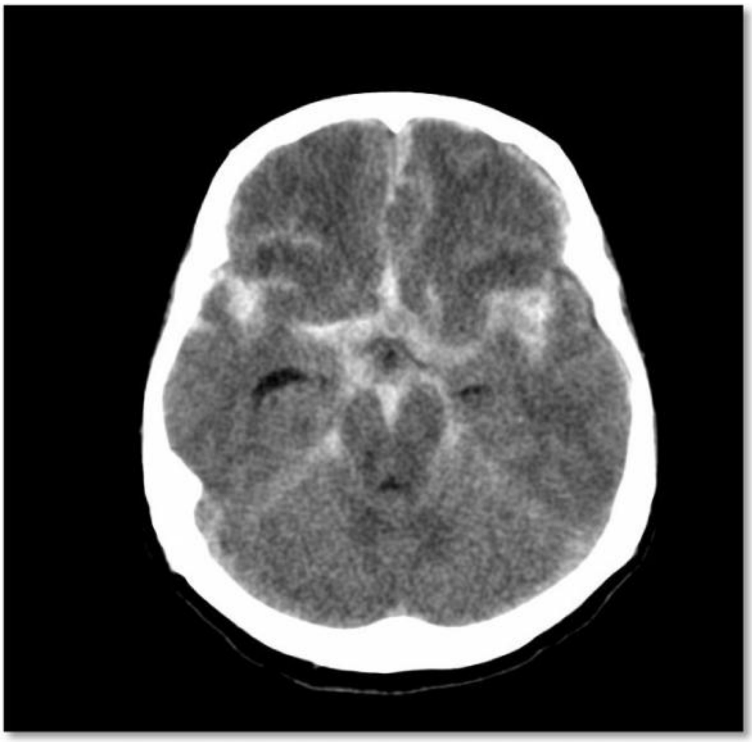


<u>Photograph 10</u>- CT scan image depicting Extradural Hemorrhage

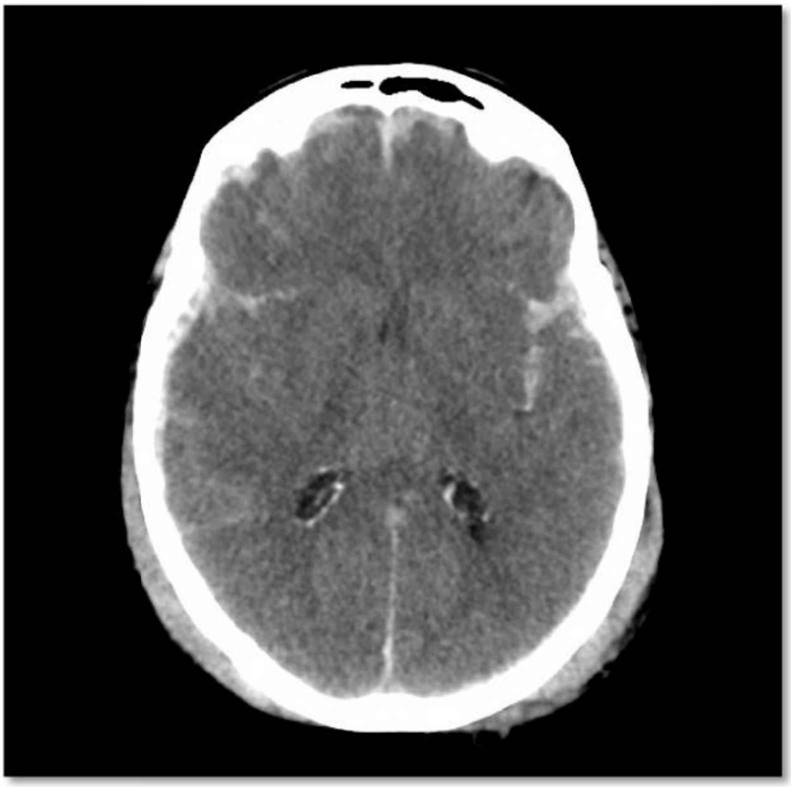
<u>Photograph 11</u>- CT scan image depicting Subdural Hemorrhage



<u>Photograph 12</u>- CT scan image depicting diffuse Subarachnoid Hemorrhage



<u>Photograph 13</u>- CT scan image depicting diffuse cerebral edema



ANNEXURE V

MASTER CHART

S.No.	AGE	SEX	MOI	TOV	POR	T1	T2	T3	SI	SF	EDH	SDH	SAH	ICH	CONT	CE
1	21	F	RTA	PR	R	1-4 H	1-7 D	2-7 D	A-C-	A+C+	A-C-	A+C+	A+C+	A-C-	A+C+	A+C+
2	34	M	RTA	2WR	R	8-24 H	4-24 H	1-2 D	A+C-	A+C-	A-C-	A+C-	A+C-	A-C-	A-C-	A-C-
3	70	F	RTA	P	R	1-4 H	1-7 D	2-7 D	A+C+	A+C+	A+C+	A+C+	A+C+	A+C+	A+C+	A+C+
4	18	M	RTA	PR	U	8-24 H	1-7 D	2-7 D	A-C-	A-C-	A-C-	A+C-	A+C-	A-C-	A+C+	A+C+
5	67	F	RTA	PR	R	4-8 H	4-24 H	<12 H	A+C-	A+C-	A-C-	A+C+	A+C+	A-C-	A-C-	A+C+
6	28	M	RTA	2WR	U	1-4 H	>7 D	>7 D	A+C-	A+C+	A-C-	A-C-	A+C-	A-C-	A+C+	A+C+
7	42	M	RTA	2WR	R	8-24 H	4-24 H	12-24 H	A+C+	A+C+	A-C-	A+C+	A+C+	A+C+	A+C+	A+C+
8	76	F	FFH	~	R	1-4 H	1-7 D	2-7 D	A+C+	A+C+	A+C+	A-C-	A+C+	A-C-	A+C+	A+C-
9	38	M	RTA	2WR	U	8-24 H	4-24 H	12-24 H	A-C-	A-C-	A-C-	A-C-	A-C-	A-C-	A+C+	A+C+
10	25	M	RTA	PR	U	4-8 H	1-7 D	2-7 D	A+C+	A+C+	A-C-	A+C+	A+C+	A+C-	A+C+	A+C-
11	27	M	RTA	2WR	R	1-4 H	1-7 D	2-7 D	A+C-	A+C+	A-C-	A-C-	A+C-	A-C-	A+C+	A+C+
12	55	M	FFH	~	R	1-4 H	4-24 H	<12 H	A+C+	A+C-	A-C-	A+C+	A+C+	A+C+	A-C-	A-C-
13	65	F	RTA	P	R	4-8 H	4-24 H	<12 H	A+C+	A+C+	A+C+	A+C+	A+C+	A-C-	A-C-	A+C-
14	40	M	RTA	P	U	1-4 H	1-7 D	2-7 D	A+C-	A-C-	A-C-	A+C-	A-C-	A-C-	A+C+	A+C+
15	40	M	RTA	2WR	R	<1 H	4-24 H	12-24 H	A+C+	A+C+	A+C+	A+C+	A+C+	A+C-	A-C-	A-C-
16	24	M	RTA	2WR	R	8-24 H	4-24 H	12-24 H	A+C-	A-C-	A-C-	A-C-	A+C-	A-C-	A-C-	A-C-
17	38	M	RTA	P	R	1-4 H	>7 D	2-7 D	A+C-	A+C+	A-C-	A-C-	A+C-	A-C-	A+C+	A+C+
18	25	M	RTA	2WR	R	4-8 H	1-7 D	2-7 D	A+C+	A+C+	A+C-	A+C+	A+C+	A+C+	A+C+	A+C-
19	50	F	RTA	PR	U	1-4 H	1-7 D	2-7 D	A+C-	A+C-	A-C-	A-C-	A+C-	A-C-	A+C+	A+C+
20	47	M	RTA	2WR	R	1-4 H	4-24 H	12-24 H	A+C-	A-C-	A-C-	A+C+	A+C+	A-C-	A-C-	A-C-
21	67	M	FFH	~	U	8-24 H	4-24 H	<12 H	A+C-	A+C+	A-C-	A+C+	A+C-	A-C-	A-C-	A+C+
22	32	M	RTA	2WR	U	1-4 H	>7 D	>7 D	A+C-	A-C-	A-C-	A+C+	A+C+	A+C+	A+C+	A+C+
23	50	F	RTA	PR	R	8-24 H	4-24 H	<12 H	A+C-	A+C+	A-C-	A+C-	A+C+	A-C-	A-C-	A-C-

S.No.	AGE	SEX	MOI	TOV	POR	T1	T2	T3	SI	SF	EDH	SDH	SAH	ICH	CONT	CE
24	69	M	RTA	2WR	U	4-8 H	4-24 H	12-24 H	A+C-	A-C-	A-C-	A-C-	A-C-	A-C-	A-C-	A-C-
25	28	M	RTA	2WR	U	1-4 H	1-7 D	2-7 D	A+C-	A+C+	A-C-	A-C-	A+C+	A-C-	A+C+	A+C+
26	50	M	RTA	2WR	U	8-24 H	<4 H	<12 H	A+C+	A+C+	A+C+	A+C+	A+C-	A-C-	A-C-	A+C+
27	32	F	RTA	PR	U	1-4 H	4-24 H	12-24 H	A+C+	A+C+	A-C-	A+C+	A+C+	A-C-	A-C-	A+C+
28	45	M	RTA	PR	R	1-4 H	1-7 D	2-7 D	A+C+	A-C-	A-C-	A-C-	A-C-	A-C-	A+C+	A+C+
29	30	M	RTA	2WR	R	<1 H	4-24 H	12-24 H	A+C-	A+C+	A-C-	A+C+	A+C+	A+C+	A-C-	A+C+
30	2	M	RTA	P	R	1-4 H	>7 D	>7 D	A+C-	A-C-	A-C-	A-C-	A-C-	A-C-	A+C+	A+C+
31	49	M	RTA	4WR	R	1-4 H	1-7 D	2-7 D	A+C-	A+C+	A-C-	A+C+	A+C+	A-C-	A+C+	A+C+
32	45	F	RTA	P	R	8-24 H	4-24 H	12-24 H	A+C-	A-C-	A-C-	A+C+	A+C+	A-C-	A-C-	A-C-
33	52	M	RTA	2WR	R	1-4 H	1-7 D	2-7 D	A+C-	A-C-	A-C-	A+C+	A+C+	A-C-	A+C+	A+C+
34	38	M	RTA	2WR	U	4-8 H	4-24 H	<12 H	A+C+	A+C+	A+C+	A+C-	A+C-	A-C-	A-C-	A+C+
35	35	F	FFH	~	U	1-4 H	>7 D	>7 D	A+C-	A-C-	A-C-	A+C+	A+C+	A+C+	A+C+	A+C+
36	37	M	RTA	2WR	R	1-4 H	4-24 H	<12 H	A+C+	A+C+	A-C-	A-C-	A+C-	A-C-	A-C-	A-C-
37	18	M	RTA	2WR	U	8-24 H	<4 H	<12 H	A-C-	A-C-	A-C-	A+C+	A+C+	A-C-	A-C-	A-C-
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39	45	F	RTA	P	R	4-8 H	4-24 H	<12 H	A+C-	A+C-	A-C-	A+C-	A+C-	A-C-	A-C-	A-C-
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S.No.	AGE	SEX	MOI	TOV	POR	T1	T2	T3	SI	SF	EDH	SDH	SAH	ICH	CONT	CE
50	22	M	RTA	2WR	R	8-24 H	<4 H	<12 H	A+C+	A+C+	A-C-	A+C+	A+C+	A+C+	A+C-	A+C+
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53	26	M	RTA	2WR	R	4-8 H	4-24 H	12-24 H	A+C+	A+C-	A-C-	A+C+	A+C+	A-C-	A-C-	A+C-
54	40	M	RTA	2WR	R	4-8 H	4-24 H	<12 H	A-C-	A-C-	A-C-	A+C+	A+C+	A-C-	A-C-	A-C-
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56	35	M	RTA	PR	U	1-4 H	1-7 D	1-2 D	A+C-	A-C-	A-C-	A+C+	A+C+	A-C-	A+C-	A+C+
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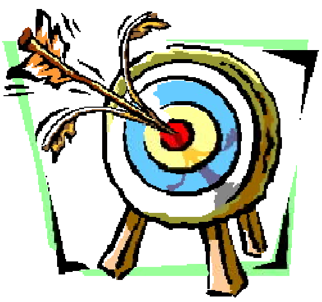
67	51	M	RTA	PR	R	4-8 H	1-7 D	2-7 D	A+C+	A+C-	A-C-	A+C+	A+C+	A+C+	A+C-	A+C+
68	38	M	RTA	2WR	R	1-4 H	4-24 H	12-24 H	A+C-	A-C-	A-C-	A-C-	A-C-	A-C-	A+C-	A+C+
69	48	M	FFH	~	U	8-24 H	<4 H	<12 H	A+C+	A+C+	A+C+	A+C+	A+C+	A-C-	A-C-	A-C-
70	55	M	FFH	~	U	1-4 H	1-7 D	2-7 D	A+C-	A+C+	A-C-	A-C-	A+C-	A-C-	A+C+	A+C+

KEY TO MASTER CHART

S.No.	-	Serial Number
F	-	Female
M	-	Male
MOI	-	Manner of Injury
RTA	-	Road Traffic Accident
FFH	-	Fall from Height
TOV	-	Type of Victim
2WR	-	2 Wheeler Rider
4WR	-	4 Wheeler Rider
PR	-	Pillion Rider
P	-	Pedestrian
POR	-	Place of Residence
R	-	Rural
U	-	Urban
T1	-	Time interval between incidence and CT scan
T2	-	Survival period

T3	-	Time interval between CT scan and death
H	-	Hours
D	-	Days
SI	-	Scalp Injury
SF	-	Skull Fracture
EDH	-	Extradural Hemorrhage
SDH	-	Subdural Hemorrhage
SAH	-	Subarachnoid Hemorrhage
ICH	-	Intracerebral Hemorrhage
CONT	-	Contusion
CE	-	Cerebral Edema
A-	-	Absent in Autopsy
A+	-	Present in Autopsy
C-	-	Absent in CT scan
C+		Present in CT scan

Introduction



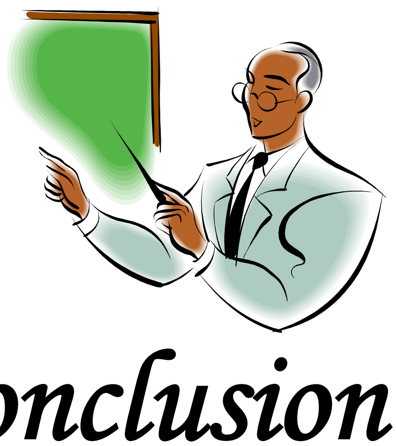
Objectives

Review of Literature

Methodology

Results

Discussion



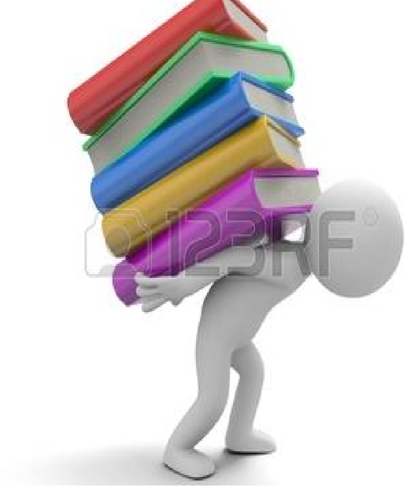
Conclusion

Summary

Bibliography

Annexure-I

Annexure-II



Annexure-III

Annexure-IV

Annexure-V