

A Study of Pattern of Injuries in Fall from Height

Bharath Kumar Guntheti¹, Uday Pal Singh²

Abstract

High incidence seen in age group 21-50 years and the height of fall varied from 0-140 feet, males, ratio is being 9:6. Married urban people of low socioeconomic income, low educated, and employed in construction works. High incidents takes place at workplace while working at roofs of buildings, during working hours in summer. We revealed that in the majority of cases the site of primary impact. The pattern of injuries depends upon the site of primary impact. Most of the victims first struck the ground either by head or by trunk or limbs and buttock. Fissure fracture of the skull when the fall occurred on to concrete from height of 5 feet and on hard soil from the height of 10 feet. Multiple rib fractures, fractures of clavicle and laceration of liver was noticed when the fall was more than 20 feet on to hard surface. Fracture of upper limbs were seen in falls on to concrete from height of 6 feet whereas the fracture of lower limb was found when the fall height was more than 15 feet on to hard surface. We noted precipitating causes like use of drugs/ alcohol, dizziness. Past history of intake of anti-hypertension drugs was found. An inappropriate fencing on terrace was the most common reason. 93.75% were accidental whereas 6.25% suicidal in nature. Cranio-cerebral damage was most common cause of death. Autopsy focus on whether the death attributed purely to the height and helps to rule out the various contributing factors. The main objective of study was to find out the pattern of injuries, manner, and causes of falls, medico legal aspect and preventive measures.

Key words: Surface of fall, Height of fall, primary site of impact, pattern of injuries

© 2016 Karnataka Medico Legal Society. All rights reserved.

Introduction:

Fall is dropping from a relatively high position by the force of gravity. The pattern of injuries in cases of fall from height is dependent on the height, weight, velocity, nature of surface impacted and orientation of body at the movement of impact, elasticity and viscosity of tissue of the contact body region. Height of fall is the major determining factor¹. Depending on the conditions affecting, the fall could be either Intrinsic [where some events or conditions affect postural control] or Extrinsic

[where an environmental factor is the main contributing reason for the fall]².

As a person falls, severity of injuries is dependent on the height of fall because Kinetic energy increases due to acceleration during the fall and is maximum at the moment of impact and is transferred to the body causing unique pattern of injuries that depends on inertia of body, moment of the body, rigidity of stationary objects and the nature of ground nature against which body falls³.

The medicolegal analysis the nature and pattern of injuries sustained to the victim to form definite opinion of nature of fall. Determination of anatomical site which first impacts the ground

¹Associate Professor, ²Prof&HoD, Dept. of Forensic Medicine & Toxicology, Mamata Medical College, Khammam; Telangana. India -5070002.

Correspondence: Dr Bharath Kumar Guntheti

Mobile No: 09908339507.

Mail id: bk62743@gmail.com

is useful in reconstruction of the event. The amount of kinetic energy acquired during the fall has to be fully expended by the time the body comes to rest so that, if only one impact occurs, it is likely to be more damaging than a series of lesser impacts, such as bouncing or rolling strike.⁴

This retrospective study has been undertaken to determine the profile, manner and pattern of injuries, factors responsible for the fall from height.

Aims and objectives:

Analysis of cases, profile, pattern of injuries in different types of impact, reasons, causes, manner of falls.

Material and Methods:

present study has been carried out in dept. of Forensic Medicine Mamata Medical College, MGH for a period of one year from March 2015 to Feb 2016. Regarding the data, nature and pattern of injuries, nature of fall, site of primary impact, height of fall, location of fall, season, landing surface, reasons for fall, cause of death,

period of survival, etc. were obtained from investigating officers. The height of fall has been determined by visiting the scene and taking measurements.

Data of history of fall from cases is collected from victims Proforma, accompanied, case sheets and police reports, medico legal autopsy done for manner, cause of injuries and compared with previous studies.

Results and Discussion:

Out of total 832 cases of medico legal autopsy cases, fall from height constituted 32 cases amounting 3.84%. These findings are similar to authors^{3,4} Injury due to fall from height remain a significant cause of morbidity and mortality.

Table no.1 Age and Gender distribution

Age group	Male	Females	Total
0-10	1	-	1[3.12%]
11-20	2	-	2[6.25]
21-30	14	1	15[46.87%]
31-40	9	1	10[31.25%]
41-50	1	1	2[6.25%]
51-60	1	-	1[3.12%]
61-70	1	-	1[3.12%]
Total	29	3	32

FIG NO.1 OCCUPATION WISE

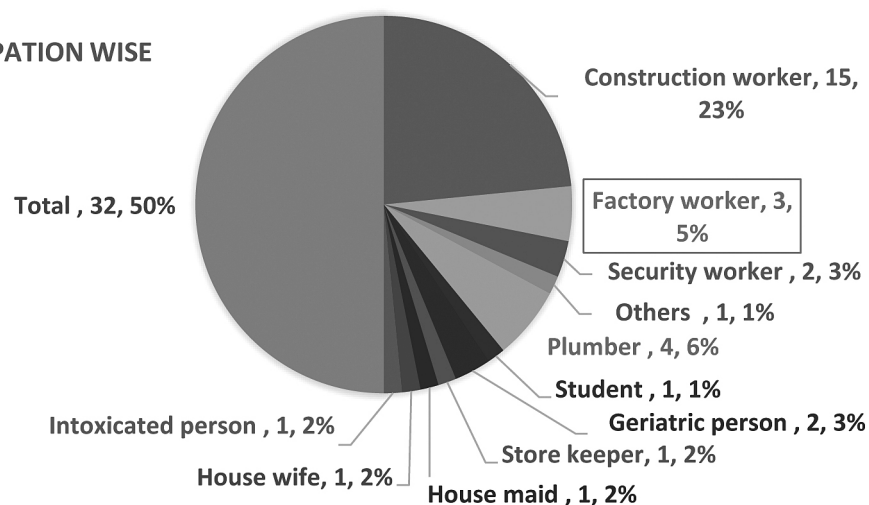


Fig no. 2: Place of Fall

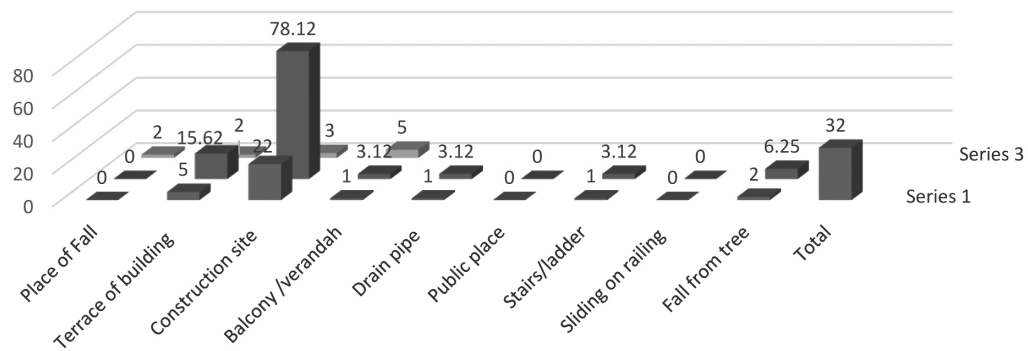


Fig no.3 Time of fall

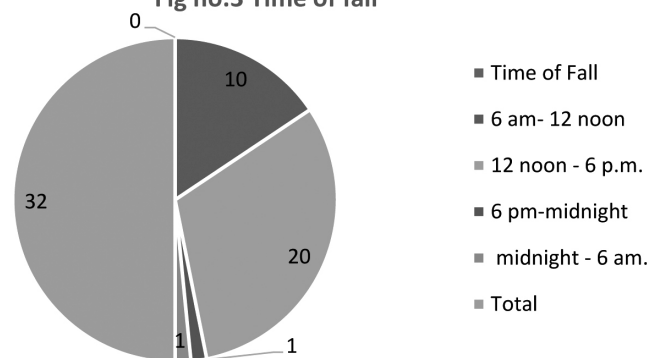
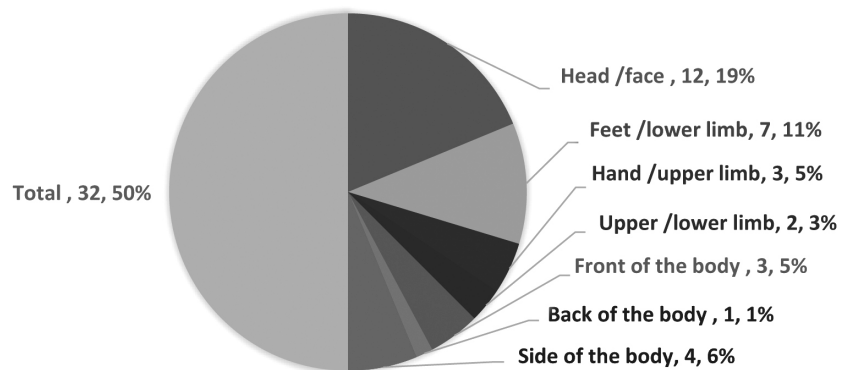
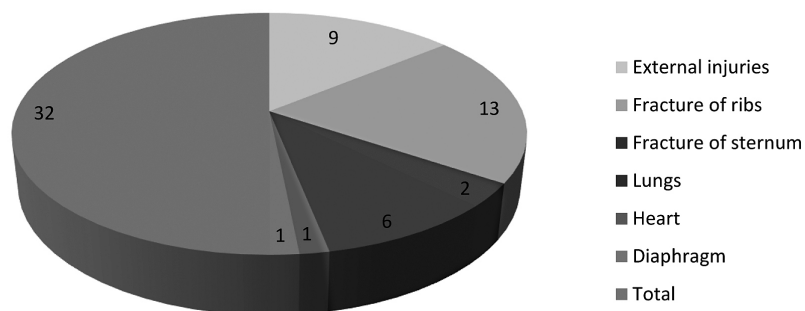
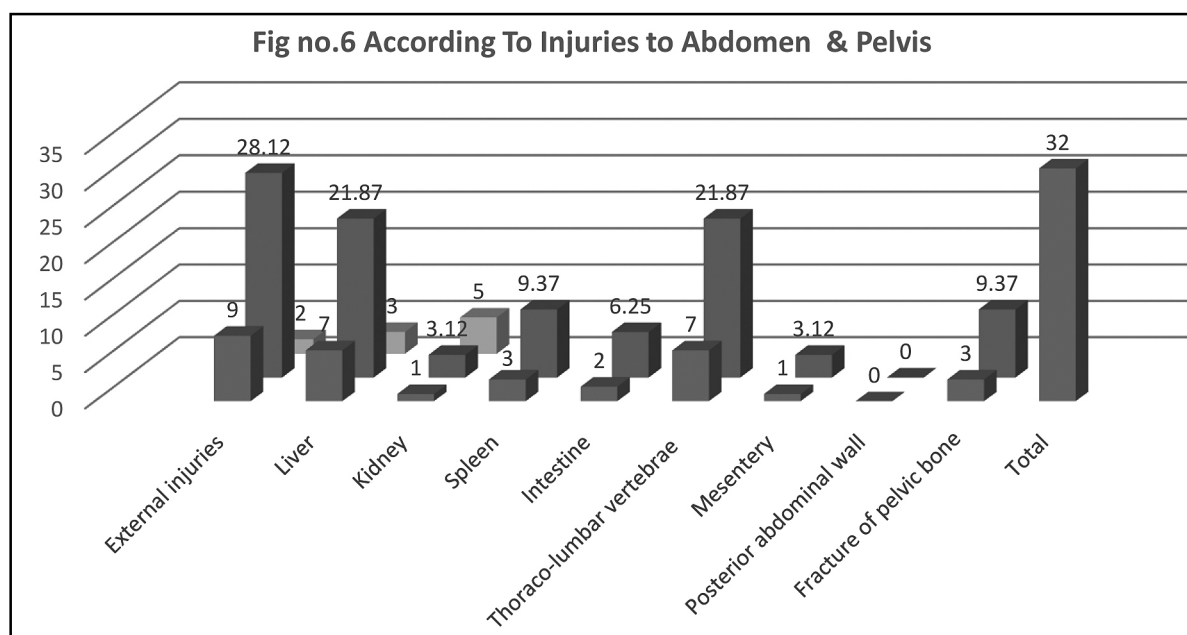


FIG NO. 4 ACCORDING TO SITE OF PRIMARY IMPACT



Figno. 5 According to Injuries to Thorax





Rendering to age wise distribution, commonest affected age group was 21-30 years in 16 [50.00%] cases followed by age group 31-40 years in 8 [25.00%] cases and 5 [15.62%] cases found in age group 41-50 years. These are consistent with authors^{3,4} as shown in Table no.1. In present study, male population 29 [90.62%] were preponderate the female 3 [9.37%] population. Male to female sex ratio being 9:6. This result coincides with the findings by authors¹⁻⁴.

We observed that the married people 30 [93.75%] are outnumbered unmarried people 2 [6.25%]. These are similar to authors²⁻⁴.

In our study, urban habitats 24 [75.00%] predominate then rural habitats 8 [25.00%]. These are consistent with authors^{4,12,13}. Most of the victims were belong to low socioeconomic group 24 [75.00%] followed by middle 6 [18.75%] cases and 2 [6.25%] cases of high socioeconomic group. These are consistent with authors^{4,9}.

In present study about 20 [62.50%] cases were gained education up to primary level, followed by 6 [18.75%] cases were gained secondary level and 2 victims were gained education up to graduation. Same results are made by authors^{4,8}.

In our study, construction workers 25 [87.50%] are top among other occupations. These are consistent with authors^{5,8} (Fig.1). As per place of

incident, maximum number of cases 22 [78.12%] were fell at construction site in household while 2 [6.25%] of cases were fell from tree. Similar results were obtained by authors^{5,6,7}. (Fig.2)

We noted that the highest number of 20 [62.50%] cases were occurred in between 12 pm- 6pm during evening time followed by 10 [31.25%] of cases were occurred from 6am to 12 in day time, only 2 [6.25%] cases occurred in night time in between 6p.m-6 am. These are similar to author⁵⁻⁷ (Fig.3).

In present study noted that the maximum cases were encountered during summer season 30 [93.75%] followed 2 [6.25%] cases were encountered during monsoon season. These are consistent with authors^{7,12}.

In our observation, epilepsy, natural diseases and use of drugs or alcohol, dizziness was the precipitating factors in 5 [15.62%] cases and 4 [12.50%] of victims showed pre-existing illness. Presence of alcohol was confirmed in 2 cases and history of anti-hypertensive medication found in 4 cases. Similar findings were noted by authors⁶⁻⁸.

According to survival period, 17 [53.12%] of victims were died in hospital within 12-24 hours after the incident, followed by 4 [12.50%] victims were died in hospital in between 24 -48 hours of fall and only 2 [6.25%] of cases were found as brought dead in our study.

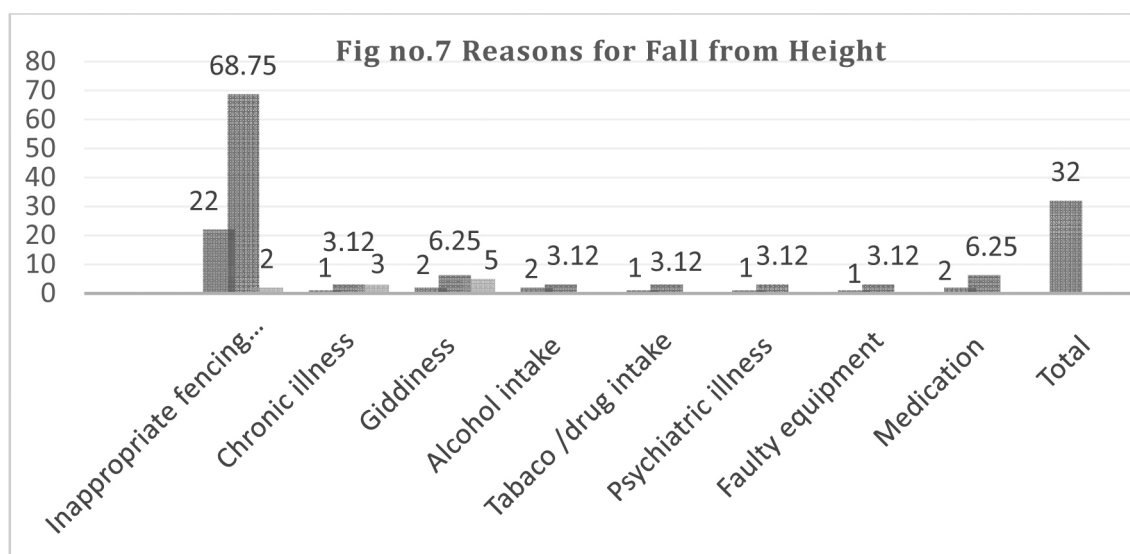


Table no 2 According to Height of Fall and Body Region Involved

Height of fall	Head	Neck	Thorax	Abdomen/Pelvis	Upper/lower limb
0-20 Feet	6	2	3	3	2
21-40 Feet	3	1	2	2	3
41-60 Feet	2	-	-	1	-
61-80 Feet	-	-	-	1	-
81-100 Feet	1	-	-	-	-
101-120 Feet	-	-	-	-	-
121 -140Feet	-	-	-	-	-
Total	12	3	5	7	5

Table no. 3 Pattern of Impact in relation to the Type of Fall

Pattern of impact	Building	Tree	%
Head	12	-	37.50
Trunk	8	-	25.00
Buttock	1	2	9.37
Leg	11	1	37.50
Unknown	-	-	-
Total	32	3	

In 2 [6.25%] cases were the shortest survival periods 1-2 hours were observed for subjects falling from heights and 7 of individuals were discharged from hospital. These are consistent with authors⁷⁻⁹.

The present study revealed the pattern of primary impact site and the pattern of injuries.

In present study, the site of primary impact is head accounted 12 [37.50%] cases. Similar

results were obtained by authors⁹⁻¹¹. Determination of primary site of impact was based on interpretation and evaluation of severe fatal injuries. Fig 4

In our study, thorax as primary trunk impact was seen in 8[25.00%] cases of fall, front of body as primary impact seen in 3[9.37%] cases, sides of body seen in 4[12.37%] cases, back of body seen only in 1[3.12%] case seen. These are consistent with other authors⁸⁻¹⁰.

Maximum number 13[40.62%] of fractured ribs were noted in primary trunk impacts and usually affected were the 2nd to 10th. Incidence of fracture of sternum 2[6.25%] was seen in trunk impacts and were associated with injuries to lungs 6[18.75%] and heart injured in one case. Maximum number of lung injuries 6[18.75%] are found in the group of trunk impacts. Similar findings were made by authors⁹⁻¹¹(Fig .5).

In present study, leg primary impacts was seen

in 12[37.50%] cases of fall from buildings which are including feet/lower limb 7 [21.87%] cases, hand/upper limb 3 [9.37%] cases and upper limb/ lower limb 2 [6.25%] cases. Maximum number of fractures of femur 4[12.50%] was noted in

primary leg impacts. Similar observations are noted by authors⁸⁻¹⁰. These findings are clearly indicative of primary leg impact and Fracture of calcaneum is an indication of feet impact (Table no.2).

Table no.4 Pattern of Impact in relation to the Height of Fall

Height of fall	Head	Trunk	Buttock	Leg	%
0-20 Feet	6	3	-	7	16[50.00%]
21-40 Feet	4	2	1	3	10[31.25%]
41-60 Feet	-	-	1	2	3[9.37%]
61-80 Feet	-	-	1	-	1[3.12%]
81-100 Feet	1	-	-	-	1[3.12%]
101-120 Feet	-	-	-	-	00
121-140 Feet	1				1[3.12%]
Total	12	8	3	12	

The present study revealed the pattern of primary impact site and the pattern of injuries.

The site of primary impact in majority of cases is head 12 [37.50%]. Similar results were obtained by authors⁹⁻¹¹. Determination of primary site of impact was based on interpretation and evaluation of severe fatal injuries. Fig 4

Thorax as primary trunk impact was seen in 8[25.00%] cases of fall, front of body as primary impact in 3[9.37%] cases, sides of body in 4[12.37%] cases, back of body 1[3.12%]. These are consistent with other authors⁸⁻¹⁰.

Maximum number 13[40.62%] of fractured ribs were noted in primary trunk impacts and usually affected were the 2nd to 10th. Fig .5

Incidence of fracture of sternum 2[6.25%] was seen in trunk impacts and were associated with injuries to lungs 6[18.75%] and heart in 1 cases. Similar findings were made by authors⁹⁻¹¹

In leg primary impacts was seen in 12[37.50%] cases of fall from buildings including feet/lower limb 7 [21.87%] cases, hand/upper limb 3 [9.37%] cases and upper limb/lower limb 2 [6.25%] cases. Maximum number of fracture of femur was noted in primary leg impacts 4[12.50%]. Similar observations are noted by authors⁸⁻¹⁰. These findings are clearly indicative of primary leg impact and Fracture of calcaneum is an indication of feet impact. Table no.2.

In primary buttock impact fall from trees

constituted 6.25% and from buildings 1 case is reported and are associated with pelvic fractures in 3[9.37%] cases. These are consistent with other authors^{8,9-11}. Table.2

Head injury in primary impacts may be due to secondary impact and is noted in 21[65.62%] cases. Brain injury was noted in all cases associated with intracranial bleeding. Subarachnoid eighboure was the commonest found in 18[56.25%] cases. These are consistent with authors⁸⁻¹⁰

Among skull fractures fissured fracture was more frequently found 18[56.25%] followed by comminuted fracture 3[9.37%]. Fissure fracture of the skull was noticed when the fall occurred on to concrete from minimum height of 3 feet and onto hard soil from the height of the 10 feet. Similar observations were noted by authors⁹⁻¹¹.

Fracture of spine, fracture spine was noted in primary impacts 7[21.87%]. The region most affected was the cervical spine 5[15.62%]. These are consistent with authors⁸⁻¹⁰.

Fracture of humors, ulna and radius were seen in 7[21.87%] cases and femur was fractured in 4 cases with primary side impact. Maximum number 6[18.75%] of lung injuries are in the group of trunk impacts. Same findings noted by authors¹⁰⁻¹²

Fracture of facial bones were seen in 2[6.25%] cases. Similar results obtained by other studies^{9,10}

Associated external injuries to other systems were found in 9[28.12%] cases and are consistent with authors⁹⁻¹²

Visceral injuries were seen in 19[54.37%] cases with liver commonly involved in 7[21.87%] cases and in 1 case the overlying ribs were fractured, liver is lacerated and mesentery is injured in two cases fig11. Similar results were establish by authors^{9,11,13}

Spleen showed multiple lacerations in 3[9.37%] cases but fracture of the overlying ribs was not seen unless height of fall was more than 20 feet

onto hard surface. Similar findings are noted by authors.⁹⁻¹¹

In our study, primary buttock impact falls were from trees constituted 6.25% and from buildings only one case is reported and are associated with pelvic fractures in 3[9.37%] cases only. These are consistent with other authors^{8,9-11}. (Table no.3)

In present study, head injury in primary impacts or may be due to secondary impact is noted in 21[65.62%] cases. Brain injury was noted in all cases associated with intracranial bleeding. Subarachnoid

Table no.5 According to Nature of the Ground and Height of fall

Height of fall	HardSurface				SoftSurface			Total
	Hard soil	Cement/Concrete	Stone	Tiles/Marbles	Tar	Mud	Sand	
0-20 Feet	8	3	1	2	1	1	-	16[50.00%]
21-40 Feet	4	4	1	-	-	-	1	10[31.25%]
41-60 Feet	1	2	-	-	-	-	-	3[9.37%]
61-80 Feet	-	1	-	-	-	-	-	1[3.12%]
81-100Feet	-	1	-	-	-	-	-	1[3.12%]
101-120Feet	-	-	-	-	-	-	-	00
121-140 Feet	1	-	-	-	-	-	-	1[3.12%]
Total	14	11	2	2	1	1	1	32

In present study, head injury in primary impacts or may be due to secondary impact is noted in 21[65.62%] cases. Brain injury was noted in all cases associated with intracranial bleeding. Subarachnoid hemorrhage was the commonest found in 18[56.25%] cases. These are consistent with authors⁸⁻¹⁰

In this study, among skull fractures fissured fracture was commonest type of fracture seen in 18[56.25%] cases followed by comminuted fracture in 3[9.37%] cases. Fissure fracture of the skull was noticed when the fall occurred on to concrete from minimum height of 3 feet and onto hard soil from the height of the 10 feet. Similar observations were noted by authors⁹⁻¹¹.

In our study, fracture of spine was noted in primary impacts 7[21.87%]. The region most affected was the cervical spine 5[15.62%]. These are consistent with authors⁸⁻¹⁰.

In present study, fracture of humerus, ulna and radius were seen in 7[21.87%] cases and femur

was fractured in 4 cases with primary side impact. Same findings noted by authors¹⁰⁻¹²

We observed that the fracture of facial bones were seen in 2[6.25%] cases. Similar results obtained by other studies^{9,10}

In our study, associated external injuries to other systems were found in 9[28.12%] cases. These are consistent with authors⁹⁻¹²

In our study, visceral injuries were seen in 19[54.37%] cases with liver commonly involved in 7[21.87%] cases and in one case the overlying ribs were fractured, liver is lacerated and mesentery is injured in two cases. Similar results were establish by authors^{9,11,13}

Spleen showed multiple lacerations in 3[9.37%] cases but fracture of the overlying ribs was not seen unless height of fall was more than 20 feet onto hard surface. Similar findings are noted by authors.⁹⁻¹¹

In our study, injury to kidney was seen in one

victim of buttock impact, it was associated with fracture of ribs. Similar findings were noted by authors¹¹⁻¹³

In this study, fracture of upper limbs were seen in 7[21.87%] falls occurred from height of 60 feet whereas the lower limb fractures were found in 5 cases when the fall height was more than 15 feet on to hard surfaces. Rupture of heart and diaphragm were seen in 1[3.12%] case of fall from a height more than 60 feet. Similar observations were made by authors¹⁰⁻¹³

According to height of fall, the maximum number of falls 16[50.00%] were from a height of 0-20feet height .In10 [31.25%] cases the height of fall was 21-40 feet. The height of fall was below 41-60 feet found in 3[9.37%] cases. In the 61-80feet range, there was only1 case seen, which was head impact. No case was observed in the range of 51-60 feet height. One case was found in the range of 61-70 feet height. Height of fall varied from 20-70 feet. One fall from tree case was found in the range of 121-140 feet of height. These are consistent with authors^{9,10,15}(Table no.4)

Type of surface ,we observed that majority of the falls 29[90.62%] cases were fell onto hard surface like cement/concrete, stone, hard soil and marble followed by 3[9.37%] cases were fell onto soft surface like sand and mud. These are consistent with authors^{9,11,16} (Tableno.5).

In our study, injuries, multi organ involvement when nature of ground was hard surfaces isolated fatal injuries were hallmark of falls over the soft surface. Same observations were noted by authors^{9,13,16}.

In present study, falling from greater than 20 feet or when the head of victim hits a hard surface such as concrete, this includes falls from roofs and terraces. These are consistent with authors^{12,14,17}

Multiple rib and clavicular fractures and laceration of liver was noticed when the height is 60 feet on to concrete. Similar results were made by authors.⁹⁻¹¹

As per base of building, most of the cases they fell close to the building 30 [93.75%] within 1

meter from the base, 2 cases were fall from tree with various distance from the main stem. Similar results were noted by authors^{10,11,18}

We observed that the improper barrier on terrace is most common reason behind accidental falls 22[68.75%].These are consistent with authors¹⁷⁻¹⁹(Fig.7)

Manner of fall, out of 32 falls 30[93.75%] of cases were accidental in nature which are including 28[87.50%] of cases falls from buildings and 2[6.25%] of cases falls from tree whereas 2[6.25%] cases of falls were suicidal in nature. In present study homicidal falls were not reported. The findings were same with authors¹⁹⁻²¹

In our study ,cranio-cerebral damage was most common cause of death found in 21[65.62%] cases of falls from lesser heights usually from 10 -12 feet, head was commonly the site of primary impact.Hemorrhagic shock was the cause of death found in 10[31.25%] cases of primary impacts including feet, trunk, leg and buttock impacts. These are consistent with authors^{7,11,22}.

Recommendations:

Loss of human life can be prevented if safety measures like self-retracting life lines, locking snap hooks, head gear, rope grab, life line anchor, lanyard and shock absorber

Conclusion:

Incidence of fall from height at work place is 3.68% and is common among construction workers of age group 21-30 years, married males, Hindus from urban area, gained primary education belong to low socioeconomic group.

Maximum number of incidents occurred during summer in the afternoon.In 48.07% of cases the height of fall was 0-20 feet followed by 21-40 feet.Primary head impact is the commonest type - below 20 feet accidents.Injury to the side of the body is common when the fall is from 60-70 feet and Abdomino thoracic injuries are common when the fall was 21-40 feet height, limb injuries noticedMulti-organ trauma is seen when

fall was on to hard surface. Deceleration injuries involving the spleen, liver with primary impact. Femur was involved with primary side impact cases. The common risk factors and etiology observed. Most of falls were accidental, head injury is the most common cause of death. Both autopsy findings, medical and past history, the findings at the scene of fall and toxicology results have to be considered. Reasons for fall, lack of safety measures, alcoholic intoxication, chronic illness and dizziness. These injuries are potentially preventable by simple legislative measures and public awareness

References:

- Atanasijevic TC, Slobodan NS, Slobodon DN, Djokic VM. Frequency and severity of in correlation with the height of fall. *J Forensic Sci* 2005;50[3]:608-612.
- Tahir Masud, Robert O Morris. Epidemiology of falls. *Age and Aging* 2001; 30[4]:3-7.
- Albert Goonetillekke U.K.D. Injuries caused by a falls from height. *Med Sci and Law* 1980;20[4]:262-275
- Lalwani S, Agnihotri AK, Talreja, Murthy OP. Pattern of injuries in fatal falls from height. A retrospective review. *Journal of Forensic Medicine and Toxicology*. 1999;16[2]:38-46
- Turk E, Tsokos M. Pathologic features of fatal falls from height. *Am J Forensic Med Pathol*. 2004; 25[3]:194-9.
- Stevens JA, Thomas KE, Sogolow ED. Seasonal patterns of fatal falls and non-fatal falls among older adults in the U.S. Accident analysis and prevention. 2007;39:1239-44.
- Stephanie A, Andrea B. Injury Pattern in correlation with the height of fatal falls. *The central European journal of medicine, Springer*. 2014; 639[9]:1-5.
- Steedman DJ. Severity of free-fall injury. 1989; 20:259-261.
- V. Prathapan, B. Umadethan. Fall from Heights—Pattern of Injuries. *Int J Biomedical Research*. 2015; 6[01]:8-13.
- CR Vasudeva Murthy, S. Harish, YP Girish Chandra. The Study of Injuries in Fatal Cases of fall from Height. *Al Ameen J Med Sci*. 2012; 5(1):45-52.
- JV Kiran Kumar, AK Srivastava. Pattern of Injuries in fall from Height. *J Indian Acad Forensic Med*. Jan-March 2013; 35 [1]: 47-50.
- Ahmad M, Rahman FN, Al –Azad MAS, Majumder MRU, Choudhury MH. Pattern of Fatal Injury in fall from Height Cases-A Medico legal Study. *JAFMC Bangladesh*. June 2014; 10(1):80-84.
- Elisabeth E, Turk and Michael Tsokos. Pathologic features of fatal fall from height. *American Journal of Forensic and Pathology*. 2004; 25(3):194-199.
- Divesh Gulati, Aditya Nath Aggarwal, Sudhir Kumar, Anil Aggarwal. Skeletal injuries following unintentional fall from height. *Turkish Journal of Trauma & Emergency Surgery*. 2012; 18[2]:141-146.
- Richeter D, Hahn MP, Ostermann PAW, Ekkernkamp A, Muhr G. Vertical deceleration injuries: a comparative study of the injury patterns of 101 patients after accidental and intentional high falls. *Injury* 1996; 27(9):655-659.
- Knights Forensic Pathology. 3rd ed. Chennai, India: Garamond by Charontech Private Limited. 2004; 15.
- Behcet AL, Cuma Yildirim, Sacid Coban. Falls from heights in and around the city of Batman. *Turkish Journal of Trauma & Emergency Surgery*. 2009; 15[2]: 141-147.
- Mac Laughlin H L. Trauma. Philadelphia: W.B Saunders Company, 1960:146-571.
- Mason J K. The Pathology of trauma. 3rd ed. New York: Arnold Publications, 2000:313-326.
- Vij Krishan. Regional Injuries. In: Textbook of Forensic Medicine and Toxicology. 3rd Ed. New Delhi: Elsevier Publication, 2005:407-445.
- Dikshit P.C. Fall from height. In: Textbook of Forensic Medicine and Toxicology. 1st edn. New Delhi: Peepee publishers and Distributors, 2007:229 – 232
- Dogra T.D, Chandra J. Blunt force lesions related to heights of a fall. *American Journal of Forensic Medicine and Pathology*. 1982; 3(1):35-43.