

Original Research Paper

Retrospective Study of Analysis of Cardiac Injuries in Autopsied Hearts at a Centre in South India

¹Srishti Mukhi, ²Shankar M Bakkannavar, ³Vinod C Nayak**Abstract:**

Background: Morbidity and mortality related to cardiac injuries are serious health concerns worldwide. The cardiac injuries could be due to traumatic blunt-force injuries or due to natural events such as injuries secondary to ischemia and infarction. The most prevalent type of lethal injuries is due to physical trauma. Cardiovascular injuries due to natural events constitute 31% of total cardiac injuries. **Aim:** The aim of this retrospective study was to give an overview of the trends in cardiac injury epidemiology in Manipal during 2011 to 2015. **Materials and Methodology:** The research was conducted in the Department of Forensic Medicine, Kasturba Medical College, Manipal. All cases due to cardiac injuries between 2011 and 2015 were included in this study. The data collected included age, sex, and type of cardiac injury, which was tabulated and analyzed for descriptive statistics using Statistical Package for Social Sciences (SPSS) version 20. **Results:** Cardiac injuries constituted 35.8% of the total number of autopsies that were conducted during the study period. 80.5% of the victims were male. Maximum number of victims were from the 3rd decade of life. Most of the cardiac injuries (38.4%) were caused by road traffic accidents. The most frequent cardiac abnormality seen in our study was subendocardial hemorrhage, 38.6 % of the total cardiac injuries. Due to traumatic events, the most frequent cardiac injury seen was contusion, 5.4% and lacerations, 4.1% of injuries. Hyperemic area was seen in 13% and white patch in 12.4% of cases. The most commonly occluded artery was the left anterior descending artery, 53.4%. The time interval between the occurrence of the incident and death of the victim ranged from few minutes to 2 months. **Discussion:** The findings of this study give us an insight to the pattern and magnitude of deaths due to cardiac injuries in a South Indian region, given that only a very low percentage of the patients who sustain cardiac injury reach hospital alive. The injury pattern helps the clinician and other researchers to concentrate on these injured parts while treating and conducting research, respectively. **Conclusion:** More autopsy studies should be conducted to define the characteristics of population based cardiac injuries.

Key Words: Cardiac Injuries; Traumatic Blunt-Force Injuries; Road Traffic Accidents; Subendocardial Hemorrhage; Hyperemic Area

Introduction:

Cardiac injury can be defined as the disruption

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of the normal cardiac myocyte membrane integrity resulting in the loss into the extracellular space (including blood) of intracellular constituents.¹ These injuries could either be due to a disease or due to any trauma.

Due to traumatic events, blunt-force injuries like lacerations, avulsions and contusions of the heart and great vessels sustained during motor vehicle crashes, constitute the most prevalent type of lethal physical trauma to the cardiovascular system. The second most prevalent type of trauma is from penetrating and perforating wounds

inflicted by firearms in the US and stab injuries in other parts of the world.²

According to Getz BS, et al.,³ the mechanism of cardiac injury in blunt trauma may be summarized as:

- (1) Direct blow to the anterior chest (most common cause of ventricular rupture);
- (2) Indirect injury that causes a sudden increase in preload, resulting in atrial rupture;
- (3) Compression of the heart between the sternum and vertebral bodies;
- (4) Acceleration/ deceleration of the heart and great vessels;
- (5) Blast injury and
- (6) Penetrating injury of a cardiac chamber by a fractured rib or the sternum.

The heart may be ruptured by compression or from a blow or a fall, usually on its right side and towards its base.⁴ Contusions or lacerations of the heart may also be produced by blows from a blunt weapon or by compression of the chest even without fracturing any bone of the thorax or showing marks of external injury.⁵ Therefore, there is always a possibility of fatal cardiac injuries to be unnoticed, leading to a fatal outcome.

Risk factors for blunt heart injury:⁶ (1) Age > 50 years, (2) History of existing cardiac disease, (3) Vehicular accident with chest impact at speed > 15 miles per hour, (4) Deformation of steering wheel, (5) Marked precordial tenderness, ecchymosis or contusion, (6) Fractured sternum, (7) Multiple injuries, (8) Fractures of thoracic spine or ribs, (9) Hemodynamically unstable condition.

The true incidence of Blunt cardiac injury (BCI) is unknown, as reported rates vary greatly in the literature, ranging between 8 and 71%. It is present in up to 20% of all motor vehicle collision deaths. Although it occurs in only 20% of all blunt thoracic trauma patients, in patients with severe thoracic injury or multiple injuries, the incidence of BCI may be as high as 76%.⁷

The incidence of BCI due to natural causes increase with the age. The risk factors for such injuries are; hypertension, cigarette smoking, diabetes mellitus, genetic (hypercholesterolemia), and obesity. Women, who are protected during reproductive years, are

prone to BCI due to increased coronary artery disease, secondary to decreased estrogen level after post menopause.

An estimated 17.7 million people died from cardiovascular diseases (CVDs) in 2015, representing 31% of all global deaths. Of these deaths, an estimated 7.4 million were due to coronary heart disease i.e 13% of the world population.⁸ CVDs have now become the leading cause of mortality in India.⁹ The Global Burden of Disease study estimate of age-standardized CVD death rate of 272 per 100 000 population in India is higher than the global average of 235 per 100 000 population.¹⁰

In order to assess the frequency and pattern, and to identify predictive factors of cardiac injuries, we reviewed the autopsy reports of 591 such fatalities between 2011 and 2015. We found that in our study the incidence of cardiac injuries was 35.8%.

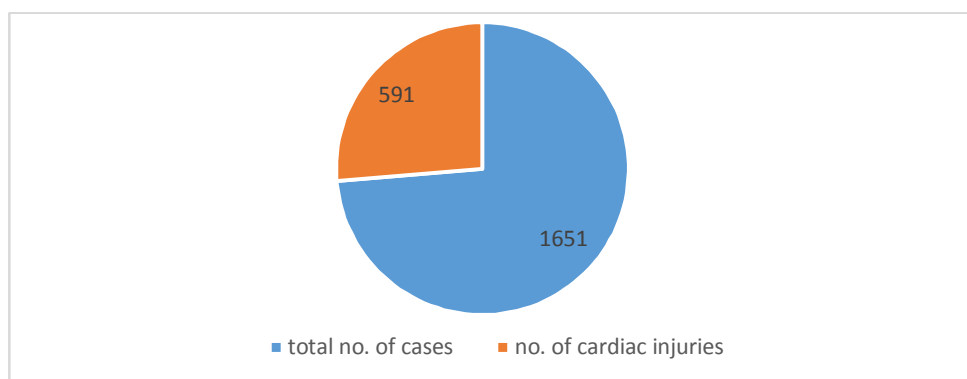
Material and Methodology:

The material for the present retrospective study were the cases of cardiac injuries brought to the mortuary of Kasturba Medical College, Manipal for post-mortem examination. Approval for the study was granted by the Institutional Ethics Committee. We reviewed 1651 cases of autopsies between the years 2011-2015. The study included cardiac injuries such as hemorrhages, white patches, and injuries (blunt force or sharp force trauma) like contusion, laceration and stab injuries. The data so collected included mainly age, sex, and type of cardiac injury. The cases were studied to be analyzed for the type of cardiac injury, the kind of impact it had and its association with the pericardial effusion and condition of the arterial walls and the cause of death. The data was tabulated and analyzed descriptive statistics using Statistical Package for Social Sciences (SPSS) version 20.

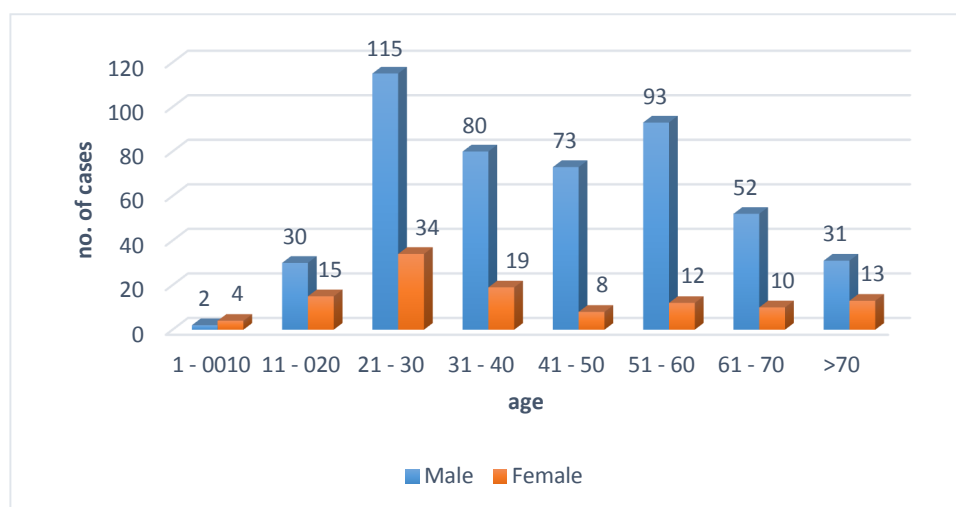
Results:

For the period 2011. 2015 we identified cardiac injuries in 591 (35.8%) of 1651 autopsied cases as shown in **Graph no. 1**. Of these, 476 (80.5%) were males, thus indicating a clear predominance of male over female.

Graph 1: The number of cardiac injuries



Graph 2: Age – sex wise distribution



Age-wise, the maximum number (25.2%) of the victims were in the age group of 21-30 years, followed by 51-60 years and 31-40 years of age group i.e., 17.8% & 16.8% cases respectively (**Graph 2**).

Table 1: Type of the Case

Type of the Case	Male	Female
Accident	207	20
Blast	0	1
Burns	16	21
Pregnancy complications	0	8
Drowning	5	1
Fall	45	1
Electrocution	4	1
Hanging	16	8
Heavy object fall	5	1
Poisoning	88	34
Homicide	3	2
Natural	82	17
Animal attack	1	0
Drug overdose	1	0
Firearm	3	0

Cases below 10 years were very few (6 cases) accounting for 1% of the total and all of them had hemorrhages in the heart.

Most of the cardiac injuries (38.4%) were caused by road traffic accidents (**Table 1**), followed by poisoning (20.64%), natural causes (16.8%) and by fall from height (7.8%). The most frequent cardiac abnormality seen in our study was subendocardial haemorrhage, 13.8% of the total cases and 38.6% of the cardiac injuries, followed by epicardial hemorrhage in 14.9% of cardiac injuries.

Due to natural events, hyperemic area was seen in 77 cases (13%), of which 76.6% were males. Most of the hyperemic areas were seen on left ventricle (71.4%) and least in the left atrium (1.3%). White patch was seen in 12.4% of the cases, of which most were seen on the right ventricle (49.3%), closely followed by left ventricle (47.9%) and 1.4% each on right

and left atrium. Pale area was seen in 16 cases, of which 15 were males (93.7%). Most of the pale areas were seen on the left ventricle, 81.3% (**Table 2 & 3**).

Table 2: Cardiac Injuries

Injury	Male	Female
Clot on pulmonary trunk	0	2
Congestion	6	2
Contusion	29	3
Hyperemic area	59	16
Laceration	18	6
Membrane defect	5	1
Thromboembolus	0	2
Vegetation	2	1
White patch	63	10
Pale area	15	1
Saccular projection	1	0
Calcification	4	0
Fibrotic patch	2	0
Hypopigmented area	5	0
Rupture of chordae tendinae	1	0
Sharp clean cut wound	1	0
Penetrating wound	1	0
Sub endocardial hemorrhage	180	48
Epicardial hemorrhage	109	40

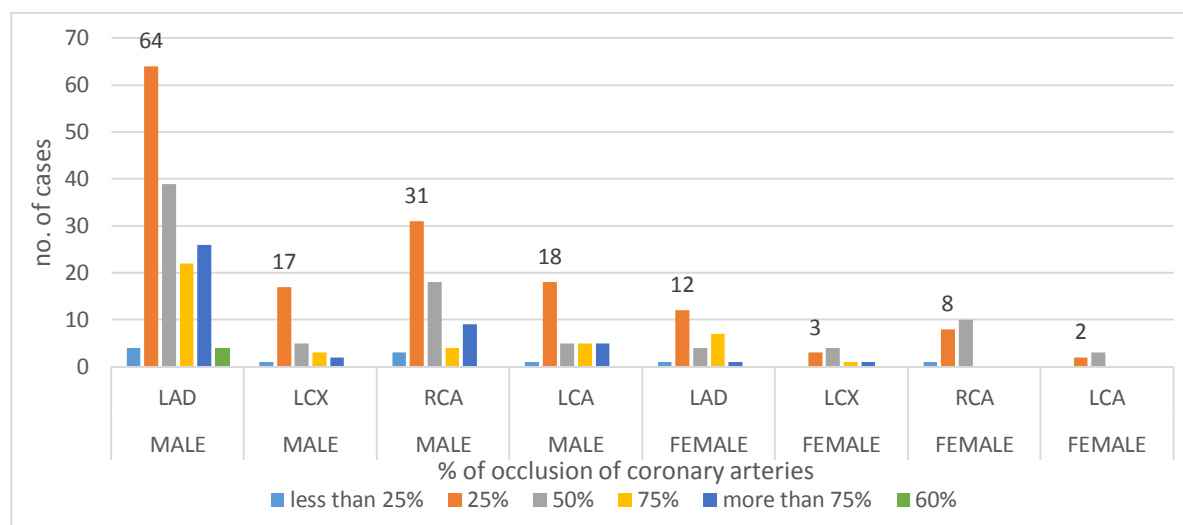
Coronary artery occlusion was found in 344 (58.2%) of 591 cardiac injury cases studied. Of these, 83.1% of occlusions were found in males. The most commonly occluded artery was the left anterior descending, 53.4% cases, followed by the right coronary artery, 24.4%. The left anterior descending artery was found to be 25% occluded in most of the cases (22.1%), followed by right coronary artery, 11.3%. as shown in **Graph 3**.

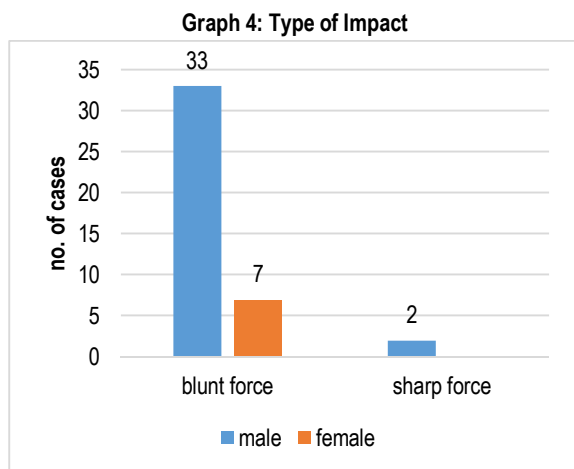
Table 3: Location of Cardiac Injuries

Cardiac Injuries	Right Ventricle	Right Atrium	Left Ventricle	Left Atrium
Hyperemic area	19	2	55	1
Contusion	10	8	10	4
Laceration	11	3	9	1
Congestion	3	0	5	0
White patch	36	1	35	1
Pale area	3	0	13	0
Saccular projection	0	0	1	0
Calcification	0	0	2	2
Fibrotic patch	0	0	2	0
Hypopigmented area	1	0	4	0
Thromboembolus	1	1	0	0
Penetrating wound	1	0	0	0
Sharp clean cut wound	0	0	1	0

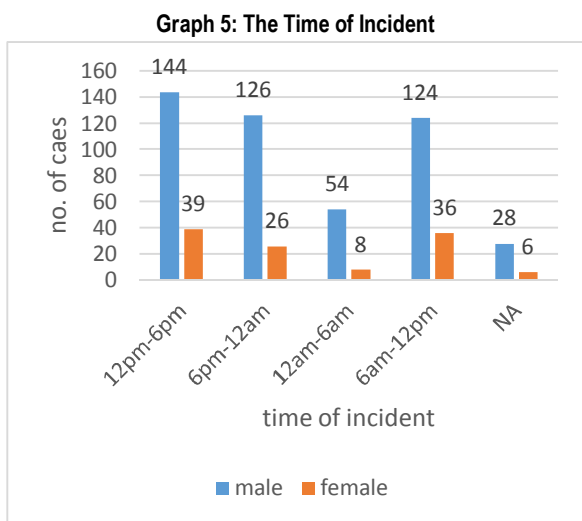
Due to traumatic events, the most frequent cardiac injury seen was contusion, 32 cases (5.4%), of which 29 were males (90.6%). Of these, 31.2% of the injuries were seen both in right and left ventricle and 25% (8 cases) on the right atrium. Lacerations were seen in 24 cases (4%), of which 11 were on the right ventricle (45.8%) and 9 on the left ventricle (37.5%). Injuries due to sharp weapon were also noted. Among these, one was a clean cut wound on the left ventricle and the other was a penetrating wound on right ventricle. Heart wounds were caused by blunt weapon/ surface in 40 cases (6.7%) and sharp weapon in 2 cases (0.3%). The type of injuries and their distribution among sexes are presented in **Graph 4**.

Graph 3: Occlusion of Coronary Arteries



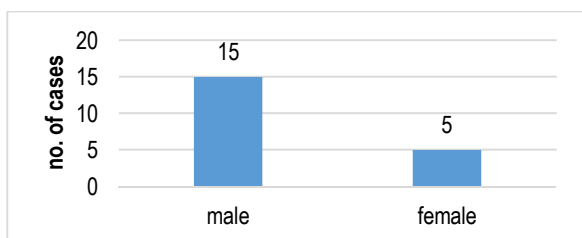


Only 20 cases (3.38%) of the cardiac injuries were associated with pericardial effusion, of which 60% of the cases were deaths due to road traffic accidents, 35% were of natural deaths and 1% of cases were due to poisoning (**Graph 5**).



The incidence of cardiac injuries was maximum during the incidences occurring between 12pm to 6pm, 183 cases (30.96%), followed by 6am-12pm (27.1%) and 6pm-12am (25.8%), as shown in **Graph 6**.

Graph 6: Association with Pericardial Effusion



The time interval between the incident and death was less than or equal to one week in 149 (25.2%) cases and less than one day in 125 (21.1%) cases and only 2 cases were found in the time interval of more than a month (**Table 4**).

Table 4: The Time Interval between Incident and Death

Time Interval	Male	Female
Less than 1 day	111	14
1 day	59	18
Less than equal to week	116	33
More than a week	50	18
1 month	3	2
More than a month	2	0
NA	135	30

Discussion

The results of the present study showed that 35.8% of the autopsied cases had cardiac injuries. Kaiser and Birnbaum¹¹ reported that injuries of the heart were present in 7.12% of all thoracic trauma cases in their study. Kulshrestha, et al.¹² reported that cardiac injuries accounted for 41% of the deaths resulting primarily from chest trauma. Although the results of the present study reveal higher percentages of cardiac injuries in autopsied cases compared to previous studies, this may be due to the fact that the definition of the cardiac injuries in the study includes injuries not only caused by road traffic accidents but also by other causes like poisoning or natural cause.

Consistent with other studies on cardiac injury,^{2,13,14} our results demonstrate male dominance (80.5%) and average age range being 21.30 years, suggesting that females are less prone to cardiac injury than males, presumably due to their roles in the professional and social environment.

Reviews of thoracic trauma in children demonstrate an extremely low incidence of cardiac injury. Smyth¹⁵ found a number of cases of cardiac injury amongst 94 children with chest trauma, while Meller et al¹⁶ reported only 2 cases of cardiac injury resulting from blunt trauma in 68 patients. In the present study, we found six children (1.01%) with cardiac injuries.

Traffic accidents are the most frequent cause of blunt cardiac injury, followed by violent fall impacts, interpersonal aggression, and various kinds of high-risk sports,^{17,18} which is consistent with the present study, which showed

that 38.4% of the deaths due to cardiac injuries caused by road traffic accidents. This can be explained by the fact that a direct blow to the chest, in combination with the direct transfer of energy during impact, can cause a sudden, forceful deceleration and compression of the heart between the sternum and the spine causing injury.

Due to traumatic events, the most common injury that is seen is contusion (5.4%). In autopsy studies following major blunt trauma, an incidence of cardiac contusion ranging from 14% -16% has been reported. Laceration was seen in 4.1% of the cases, of which 45.8% were seen on the right ventricle, followed by the left ventricle - 37.5%, right atrium and left atrium, in descending frequency, which is consistent with other studies.^{19,20,21} The preponderance of right ventricular injury over the left in blunt trauma can be explained by the fact that the sternocostal surface of the heart is mainly formed by the right ventricle, so the major brunt of the trauma is borne by the right ventricle.²

While some studies identified penetrating trauma as the major cause of cardiac injury,^{19,21-25} other authors^{17,26} reported a higher rate of cardiac injury due to blunt trauma which is similar to our study.

Subendocardial haemorrhage was seen in 13.8% of the total number of the cases, which is consistent with the other studies.²⁷ It was seen more common than the epicardial haemorrhages, as subendocardium is the least perfused region of the heart.²⁸

Hyperemic area was seen in 13.9% of the cardiac injuries, both in traumatic and natural causes of death, which is basically an active process in which arteriolar dilation leads to increased blood flow.²⁸ Most of the hyperemic area was seen on the left ventricle, 71.4%, because left ventricular epicardial region gets perfusion in both systole and diastole, while the subendocardial region gets solely during diastole.

White patches constitute about 12.5% of the cardiac injuries signifying scarring process after an attack of myocardial ischemia.²⁸ However, studies have not been done regarding the incidence of white patches therefore statistics cannot be matched.

When the incidence of coronary involvement was considered, Left Anterior Descending was seen in 53.4% cases, Right Coronary Artery in 24.4% and Left Circumflex Artery in 10.8% cases, respectively. This was in concordance with the data given by Sudha, et al,²⁹ who showed Left Anterior Descending as the most common site for plaque (47%), and Yazdi, et al,³⁰ who showed Left Anterior Descending as the most commonly involved artery (60%), followed by Right Coronary Artery (50%) and Left Circumflex Artery (42.5%).

Most of the individuals showed left anterior descending artery having 25% narrowing (22.1%) in our study. However, study done by Andrew et al³¹ showed ~75% cross-sectional luminal narrowing of left anterior descending artery in 52% of cases of sudden coronary death. This can be due to the fact that their study includes cases only from MI or CAD.

Pericardial effusion was found in 3.4% of subjects in general autopsy studies which is in concordance with our study which showed 3.4% of the cases having pericardial effusion.³²

A group from Harvard, estimated that on an average, the extra risk of having a myocardial infarction, or heart attack, between 6 a.m. and noon is about 40% which is not in accordance with our study, which showed maximum cases between 12 pm-6pm, because our study included injuries caused by both natural and traumatic causes.

Conclusion:

Cardiac injuries are the injuries which must be addressed immediately so as to prevent possible mortality and morbidity. Proper knowledge about these injuries, arising due to traumatic or non-traumatic events, can help the clinician or health care provider to manage the case effectively. In this regard, the present study throws some light on the cardiac injuries. Though there are less studies in this regard, further studies considering few more parameters can be taken up so that compressive knowledge about these injuries can be obtained and shared among the researchers of the globe.

Conflict of interest: None

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References:

1. Available from: <https://www.uptodate.com/contents/biomarkers-of-cardiac-injury-other-than-troponin>. Accessed on 8.10.2017
2. Recep Fedakar, Nursel Türkmen, Dilek Durak, Ümit Naci Gündoğmuş : Fatal traumatic heart wounds: review of 160 autopsy cases. *Isr Med Assoc J.* 2005; 8:498-501.
3. Getz BS, Davies E and Steinberg SM. Blunt cardiac trauma resulting in right atrial rupture, *JAMA* 1986;255:761-3.
4. Reddy KSN. Regional Injuries. The essentials of forensic medicine and toxicology; K. Suguna Devi, Hyderabad, 21st Edn. 2002;p.223-8.
5. Modi JP. Regional injuries. Modi's medical jurisprudence and toxicology; C.A. Franklin, N.M. Tripathi Pvt. Ltd., Bombay, 21st Edn, 1989:p319-27.
6. Pryor JP, Schwab W, Peitzman AB. Chapter 26A: Thoracic injury. pages 203-3. (Figure 26A.5, page 215). IN: Peitzman AB, Schwab CW, Yealy DM, Rhodes M, Fabian TC. The trauma manual: Trauma and Acute care surgery, 2nd Ed. Riverwoods, US: Lippincott Williams & Wilkins. 2002.
7. Available from: <http://www.aast.org/blunt-cardiac-injury>. Accessed on 24.07.2017
8. Available from: http://www.who.int/cardiovascular_diseases/en/. Accessed on 9.08.2017
9. Garg M, Aggarwal AD, Kataria SP. Coronary atherosclerosis and myocardial infarction an autopsy study. *J Ind Acad Forensic Med* 2011;31(1):39-42
10. Prabhakaran Dorairaj, Jeemon Panniyammakal, Roy Ambuj. Cardiovascular Diseases in India Current Epidemiology and Future Directions. *Circulation.* 2016; 133:1605. 1620.
11. Kaiser ME, Birnbaum DE. Injuries of the heart-diagnosis and therapy [Abstract]. *Kongressbd Dtsch Ges Chir Kongr* 2001;118:568-71. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/11824316>. Accessed on 10.12.2018
12. Kulshrestha P, Iyer KS, Das B, Balram A, Kumar AS, Sharma ML, Rao IM, Venugopal P. Chest injuries: a clinical and autopsy profile. *J Trauma* 1988;28:844-7.
13. Meera TH, Nabachandra H. A Postmortem study of cardiac injuries *J Ind Acad Forensic Med* 2005;27(2):82-4.
14. Kumar A, Singh M, Verma AK, Rastogi AK. Blunt injuries of chest: a medicolegal analysis. *J Indian Acad Forensic Med* 2012;34(2):108-10.
15. Smyth BT. Chest trauma in children. *J Pediatr Surg* 1979;14(1):41-7.
16. Meller JL, Little AG, Shermeta DW. Thoracic trauma in children [Abstract]. *Pediatrics* 1984;74:813-9.
17. Alanezi K, Milencoff GS, Baillie FG, Lamy A, Urschel JD. Outcome of major cardiac injuries at a Canadian trauma center. *BMC Surg* 2002;2:4.
18. Fulda G, Brathwaite CE, Rodriguez A, Turney SZ, Dunham CM, Cowley RA. Blunt traumatic rupture of the heart and pericardium: A ten-year experience (1979. 1989) *J Trauma* 1991;31:167-73.
19. Asensio JA, Berne JD, Demetriades D, Chan L, Murray J, Falabella A, et al: One hundred five penetrating cardiac injuries: a 2-year prospective evaluation. *J Trauma* 1998;44:1073-82.
20. Clarke DL, Quazi MA, Reddy K, Thomson SR: Emergency operation for penetrating thoracic trauma in a metropolitan surgical service in South Africa. *J Thorac Cardiovasc Surg* 2011;142:563-8.
21. Carr JA, Buterakos R, Bowling WM, Janson L, Kralovich KA, Copeland C, et al: Long-term functional and echocardiographic assessment after penetrating cardiac injury: 5-year follow-up results. *J Trauma* 2011;70:701-4.
22. Molina EJ, Gaughan JP, Kulp H, McClurken JB, Goldberg AJ, Seamon MJ: Outcomes after emergency department thoracotomy for penetrating cardiac injuries: a new perspective. *Interact Cardiovasc Thorac Surg* 2008;7:845-8.
23. Seamon MJ, Shiroff AM, Franco M, Stawicki SP, Molina EJ, Gaughan JP, et al: Emergency department thoracotomy for penetrating injuries of the heart and great vessels: an appraisal of 283 consecutive cases from two urban trauma centers. *J Trauma* 2009;67:1250-7.
24. Comoglio C, Sansone F, Boffini M, Ribezzo M, Rinaldi M: Nail gun penetrating injury of the heart mimicking an acute coronary syndrome. *Int J Emerg Med* 2010;3:135-7.
25. Topaloglu S, Aras D, Cagli K, Ergun K, Deveci B, Demir AD, et al: Penetrating trauma to the mitral

- valve and ventricular septum. *Tex Heart Inst J* 2006;33:392-5.
26. Kulshrestha P, Das B, Iyer KS, Das B, Balram A, Kumar AS, Sharma ML, Rao IM, Venugopal P. Cardiac injuries: a clinical and autopsy profile. *J Trauma* 1990;30:203-7.
27. Bakkannavar SM, Babu YPR, Ashwinikumar, Nayak VC, Manjunath S, Kumar GP. Subendocardial haemorrhage in autopsied hearts. *J Pharm Biomed Sci* 2013;26(26):410-5.
28. Schoen FJ, Mitchell RN. The Heart. In: Kumar Vinay, Abbas Abul, Aster Jon. Editors. Robbins and Cotran: Pathologic basis of Disease; South Asian 9th edition. New Delhi: Reed Elsevier India Private Limited. 2015:544.
29. Sudha ML, Sundaram S, Purushothaman KR, Kumar PS, Prathiba D. Coronary atherosclerosis in sudden cardiac death: An autopsy study. *Indian J Pathol Microbiol* 2009;52(4):486-9.
30. Yazdi SAT, Rezaei A, Azari JB, Hejazi A, Shakeri MT, Shahri MK. Prevalence of atherosclerotic plaques in autopsy cases with noncardiac death. *Iranian J Pathol* 2009;4(3):101-4.
31. Andrew Farb, Anita L. Tang, Allen P. Burke, Laura Sessums, Youhui Liang, Renu Virmani. Sudden coronary death frequency of active coronary lesions, inactive coronary lesions, and myocardial infarction. *Circulation*. 1995;92(7):1701-9.
32. Available from: <http://emedicine.medscape.com/article/15732-overview#a1>. Accessed on: 4.08.2017.