

Cardiac findings of sternal fractures due to thoracic trauma: A five-year retrospective study

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ABSTRACT

BACKGROUND: This study mainly aimed to determine the frequency of sternal fractures in thoracic trauma patients and to assess the differences in surgical need, cardiac findings, and treatment processes between patients with fracture on different sternal zones and displaced and non-displaced sternal fractures.

METHODS: We analyzed the data of patients with sternal fracture due to thoracic trauma admitted to a state hospital between January 2011 and December 2015. Patient data comprised demographics, trauma characteristics, clinical findings, and treatment process.

RESULTS: Of the 2764 thoracic trauma patients admitted during the study period, 72 (2.6%) had sternal fracture. The median age was 52 (inter quartile range: 61–38) years; the patients were predominantly male (F/M: 18/54). The most common causes of sternal fractures were motor vehicle accident, fall, and work accident. Of all the patients, 15 had displaced fracture. Abnormal echocardiogram findings were significantly more frequent in patients having fractures on the manubrium than in those having fractures on the corpus of the sternum. Patients who had fracture on the corpus had significantly lesser surgery need than those who had fracture on the manubrium of the sternum. Also, there was statistically significant difference between displaced and non-displaced sternal fracture cases in terms of surgery need ($p < 0.005$).

CONCLUSION: Abnormal echocardiography findings were more frequent in patients with sternal fracture on the manubrium and displaced fracture.

Keywords: Cardiac findings; sternal fracture; thoracic trauma.

INTRODUCTION

The number of emergency department visits for unintentional injuries is 31.0 million, and also trauma accounts for >100,000 deaths annually in the United States.^[1] Blunt thoracic trauma accounts for nearly 10% of all trauma cases admitted to emergency departments.^[2,3]

Trauma-related thoracic injuries are considerable causes of morbidity and mortality in trauma cases. These injuries attribute to roughly 25% of trauma-related deaths in the United States.^[4] In a ten-year retrospective study on 4205 patients with chest trauma, the morbidity rate was 25.2% and the fatality rate was 9.3% for all cases in a level I trauma

hospital in Turkey.^[5] In this study, authors found that rib fractures were diagnosed in 1424 cases, of which 1008 (23.9%) had one or two rib fractures and 344 (8.1%) had >2 rib fractures; however, clavicle ($n=65$, 1.5%) and sternum ($n=33$, 0.7%) fractures were detected less commonly.^[5] In another study, 48 of 448 (10.7%) blunt chest trauma patients had sternum fracture.^[6]

A wide range of outcomes such as pleural effusion, hemothorax, pneumothorax, pericardial effusion, pneumomediastinum, and retrosternal hematoma can occur after sternum fracture (SF).^[7,8] Studies have shown that the incidence of cardiac injury related with sternal fracture ranges from 18.0% to 62.0%.^[9,10] Rarely, cardiac tamponade can occur due

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to extrapericardial blood collection without intrapericardial hematoma or injury, requiring surgical procedures.^[1]

This study mainly aimed to determine the frequency of sternal fractures in thoracic trauma patients and to assess the differences in cardiac findings, surgical needs, and treatment processes between patients with fractures on different sternal zones and displaced and non-displaced fractures.

MATERIALS AND METHODS

This study was performed at a tertiary hospital, which is a single-state hospital in a medium sized city in the Central Anatolian region of Turkey. Only this hospital has a thoracic surgeon across the city. Trauma patients from the neighboring cities are transferred to this hospital because of the lack of a thoracic surgeon during the summer (June to August) months.

The study was approved by the Hittite University Institutional Review Board with the approval number 2016-53, and the tenets of the Declaration of Helsinki were followed. After the approval, we retrospectively reviewed the hospital records of thoracic trauma patients between January 2011

and December 2015 (60 months). The inclusion criteria were as follows: (1) admission with thoracic trauma, (2) presence of sternal fracture on computed tomography (CT), (3) age over 18 years. Patients with missing clinical and laboratory data or radiographic findings were excluded from the study.

Totally, 2764 thoracic trauma patients were admitted during the study period. Of these patients, 1135 (41.1%) had multiple rib fractures, 972 (35.2%) had one rib fracture, 218 (7.9%) had hemopneumothorax, 172 (6.2%) had hemothorax, 157 (5.7%) had pneumothorax, 72 (2.6%) had sternal fracture, 25 (0.9%) had flail chest, and 10 (0.4%) had diaphragm rupture.

Initially, all patients were evaluated, and then, all stable patients were scanned with CT. Sternal fractures were diagnosed and fracture zones were detected using CT scanning (Fig. 1). If needed, immediate surgical operations were performed. The indications for surgery were as follows: (a) the presence of displaced fracture, (b) paradoxical chest movement (c) severe pain, and/or (d) cases not reduced with simple maneuvers. During surgery, the sternum was approached via vertical mid-line incision, and the ends of the fracture were fixed with titanium reconstruction plates (Litos, Hamburg, Germany).

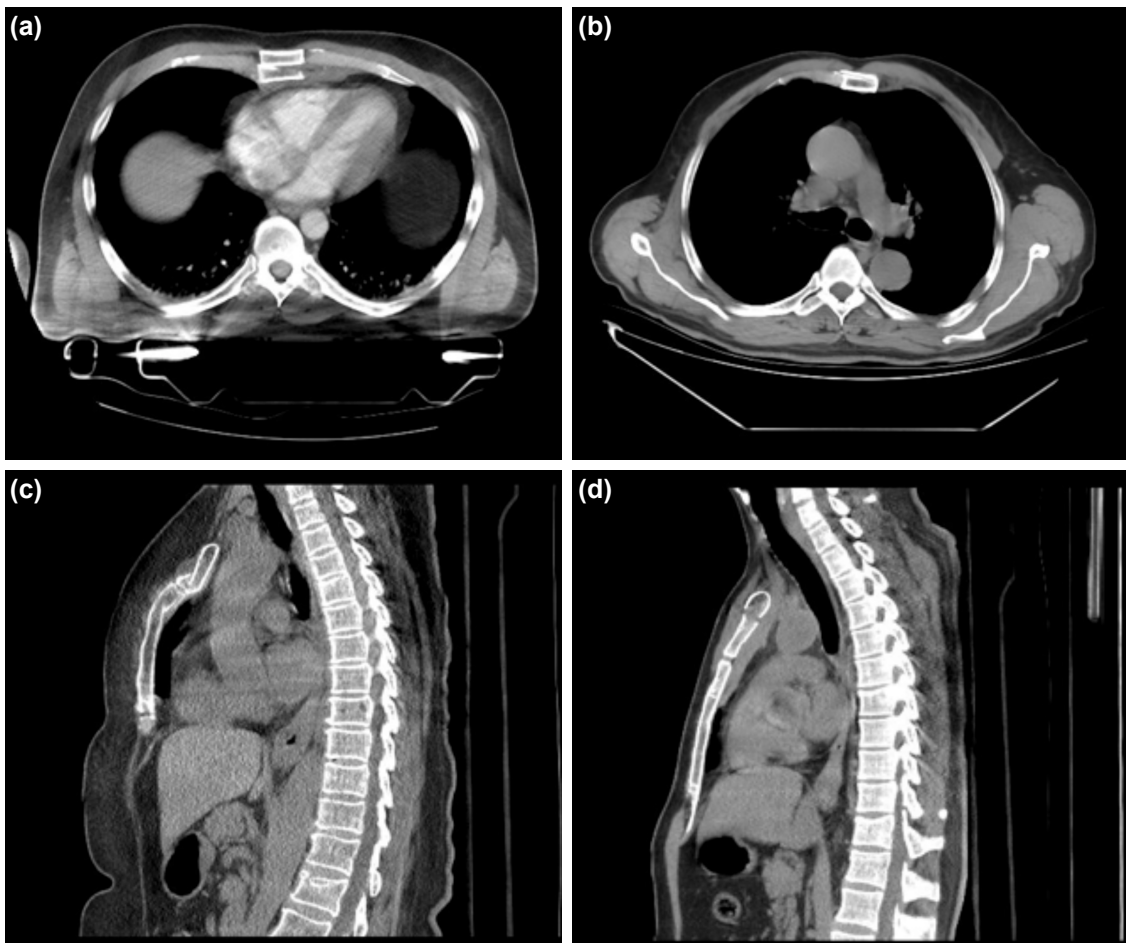


Figure 1. Axial and sagittal planes of CT scan of the patients were constructed. Figures show displaced fracture (a) and non-displaced fracture on the corpus (b); displaced fracture (c) and non-displaced fracture on the manubrium (d).

Table 1. Baseline characteristics of the study population

Characteristics	
Median age (IQR)	52 (61–38)
Sex (Female/Male)	18/54
Cause of trauma (n/N)	
Motor vehicle accident	41/72
Fall	18/72
Work accident	8/72
Violence	3/72
Animal-related injury	2/72
Sternal fracture zone (n/N)	
Corpus	50/72
Manubrium	19/72
Corpus and manubrium	3/72
Type of fracture (n/N)	
Displaced	12/72
Non-displaced	60/72
Type of care (n/N)	
Inpatient	57/72
Outpatient	15/72

Patient Data

Patient demographics (age and sex), cause of trauma, zone of sternal fracture (manubrium and corpus), type of fracture (displaced, non-displaced), findings of electrocardiography (ECG) and echocardiography, elevation of cardiac enzyme, type of treatment (clinical follow-up, operation), presence of complication, type of care (inpatient, outpatient), and length of stay were analyzed.

Pericardial effusion, myocardial contusion, and vascular pathologies were considered as abnormal echocardiography findings. ST segment changes were accepted as abnormal ECG findings. Troponin I (Tn-I) and creatine kinase-MB (CK-

MB) isoenzyme tests were evaluated; Tn-I levels >0.06 ng/mL and CK-MB (percentage of total CK) ≥5% were considered as cardiac enzyme elevation.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 23.0 software (SPSS Inc., Chicago, IL). Median and inter quartile range (IQR) were used as descriptive statistics for continuous variables. To compare qualitative variables, Fisher’s Exact Test was used. Mann–Whitney U test was used for the analysis of non-parametric continuous data. P<0.05 was considered statistically significant.

RESULTS

During the study period, 72 patients with sternal fracture (2.6%) were admitted to the hospital. The median age of patients with sternal fracture was 52 (IQR: 61–38) years, and they were predominantly male (F/M: 18/54). Of the 72 sternal fracture cases, 41 were caused by motor vehicle accident, 18 by fall, eight by work accident, three by violence, and two by animal-related injury. Most of the fractures were observed on the corpus of the sternum (n=50); fractures on the manubrium of the sternum were observed in 19 cases. Conversely, there were fractures on both the manubrium and corpus in three cases. Of all cases, 15 had displaced sternal fracture. Although the majority of the patients (57/72) were inpatient, 15 of them were outpatient (Table 1).

No statistically significant difference was seen regarding the presence of abnormal ECG findings in patients with fracture on the manubrium and corpus of the sternum. Also, no significant difference was seen in the presence of abnormal ECG findings among patients with displaced and non-displaced fracture. Abnormal echocardiography findings were detected in four of the 15 patients with the manubrium fracture; none of the patients with corpus fracture had abnormal echocardiography findings. This difference was statistically significant (p=0.004). Cases with displaced sternal fracture had significantly more frequent abnormal echocardiography findings

Table 2. Clinical findings according to the sternal fracture zone and type of fracture

	Clinical findings					
	Abnormal ECG (n/N)	p*	Abnormal Echo (n/N)	p*	Cardiac enzyme elevation (n/N)	p*
Sternal fracture zone						
Manubrium	4/19	0.062	4/15	0.004	3/15	0.119
Corpus	2/44		0/40		2/40	
Type of fracture						
Displaced	3/12	0.107	3/12	0.023	3/12	0.096
Non-displaced	4/54		2/46		3/46	

*Fisher’s Exact Test was used. ECG: Electrocardiography.

Table 3. Treatment process according to the sternal fracture zone and type of fracture

	Treatment process			
	Surgery need (n/N)	p	Length of stay (median day/IQR)	p
Sternal fracture zone				
Manubrium	5/20	0.109*	4.0/6.0–3.0	0.288**
Corpus	4/49		6.0/8.0–3.0	
Type of fracture				
Displaced	11/12	<0.005*	6.0/7.0–5.0	0.153**
Non-displaced	0/60		5.0/7.0–3.0	

*Fisher's Exact Test was used. **Mann-Whitney U test was used. IQR: Inter quartile range.

than non-displaced sternal fracture cases (4/15 and 2/46 respectively, $p=0.023$). No statistically significant difference was seen regarding the presence of cardiac enzyme elevation between subjects with fracture on the manubrium and corpus. Also, similar results were seen in patients with displaced and non-displaced fracture (Table 2).

Five of 20 patients with fracture on the manubrium had surgery need; patients with corpus fracture had less surgery need (4/49). This difference was not statistically significant ($p=0.109$). Two patients underwent surgery due to paradoxical chest movement. One of these patients had manubrium fracture and the other had corpus fracture. There was statistically significant difference between displaced and non-displaced sternal fracture cases in term of surgery need ($p<0.005$). Of 12 patients with displaced fracture, 11 had surgery need; none of the patients who had non-displaced fracture had surgery need. Conversely, the length of stay of the patients was similar between the patients with different fracture zone and fracture type ($p=0.288$ and $p=0.153$, respectively) (Table 3).

DISCUSSION

We found that the median age of the patients was 52 years, and they were predominantly male. The three most common causes of the fracture were motor vehicle accident, fall, and work accident. Rashid et al.^[8] found that the main causes of injury in patients with sternal fracture were motor vehicle accident (19/29, 66%), fall (9/29, 31%), and assault (1/29, 3%) in their study of 418 patients with blunt chest trauma of whom 29 had a fractured sternum. These results were similar to ours. They also reported that patient age ranged 30–92 years and the mean age was 64 years; 17 patients were women and 12 were men.^[8] Velissaris et al.^[12] reviewed 73 patients with sternal fracture over a 7-year period; 51 of the cases were male with a median age of 51 years. In another study with 14,553 patients in two multicentre trauma cohorts, 292 (2.0%) subjects were diagnosed with SF (2.0%) and 94% of them were visible on chest CT scan. The authors also reported that the median age of patients was 54 years, 65.3% of them were

male, and most frequent cause of trauma was motor vehicle accident (71.9%).^[13] In their five-year retrospective study, Wojcik and Morgan^[10] also found that the most common cause of sternal fracture was motor vehicle accident (59%).

Monaco et al.^[7] reported that 16 of the 50 patients (32%) with sternal fracture had displaced fracture. In our study, we found that the frequency of displaced sternum fracture was 15/75 (20%).

Skinner et al.^[14] found that the incidence of blunt cardiac injury was 50% in their retrospective observational study of 169 patients with blunt thoracic trauma. Wojcik and Morgan^[10] reported that the frequency of myocardial contusion was 18% in patients with trauma-related sternal fracture. Athanassiadi et al.^[15] found that four of the 100 patients with trauma-related sternal fracture had cardiac injury. Knobloch et al.^[16] analyzed 42,055 motor vehicle accidents and reported that there were 12 cardiac contusions among 267 patients with sternal fracture. In patients with sternal fractures, cardiac injury should be excluded. ECG changes and elevated troponin levels should indicate cardiac injury. If there is continued crushing-type chest pain, cardiac murmur, ECG changes or cardiovascular instability, the patient should be monitored with telemetry for 48 h and an echocardiogram should be performed.^[17]

Johnson and Branfoot^[18] reported that only five cases had abnormal ECG findings and none had cardiac enzyme elevation in their seven-year retrospective study with 103 patients. Perez et al.^[13] found that of the 184 patients who underwent a cardiac contusion testing, 24.4% had abnormal ECG, 15.9% had abnormal troponin levels, and 8.8% had abnormal echocardiography findings. Wiener et al.^[19] reviewed 50 cases with sternal fracture after blunt chest trauma. They found that 11 patients had one or more abnormal cardiac test (eight abnormal Echo, four abnormal ECG, and three elevated cardiac enzyme), but only three of them had clinically symptomatic myocardial contusion. They suggested that echocardiography should be used as a diagnostic tool in every patient with sternal fracture.

Sadaba et al.^[20] reported nine patients (25%) with acute changes in ECG of the 37 patients with sternal fracture over a 2-year study period. Of these nine patients, two had pericardial effusions in echocardiography. Authors also reported that five patients (14%) had cardiac enzyme elevation, and one of these patients had small pericardial effusion. In another study with 72 patients admitted to a hospital during five years, authors reported that 66 of them had cardiac enzyme measurements, and 47 of these cases (56%) had elevations in one or more of the cardiac enzymes. Only one of 72 patients had acute changes in ECG examination.^[21]

Von Garrel et al.^[22] analyzed 200 patients with sternal fractures and found that 89.2% of them had motor vehicle crashes, 76.5% had fracture on the corpus sterni, 24.5% had displaced fracture, 11.5% (23) had abnormal ECG or cardiac enzyme elevation, and 10% (20) had pericardial effusion in echocardiography. Authors also found a significant positive correlation between the degree of displacement and the appearance of pericardial effusion. We found that abnormal echocardiography findings were significantly more frequent in cases with manubrium fracture than in those with corpus fracture and displaced fracture. There was no statistically significant difference in ECG findings and presence of cardiac enzyme elevation between sternal fracture zone and fracture type groups.

We found that subjects with corpus fracture had statistically significantly lesser surgery need than those with manubrium fracture; also, the median length of stay of the patients with manubrium fracture was 4 days and of those with corpus fracture was 6 days. Perez et al. reported that median hospital length of the stay was 5 days in patients with trauma-related sternal fracture.^[13]

Limitations and Strengths of the Study

One of the limitations of the study is the external validity of the results. This study was conducted at a tertiary hospital with patient record data; therefore, the results may not be generalizable for the whole population. The other limitation of the study is the quality and missing data of the patients' records. However, some transferred patients from the other centers had printed reports of the laboratory or radiological test from referrer center. These patients' laboratory or radiological data were not available in the hospital records.

The main strengths of the study are the data from the five-year period and the analysis according to the different sternal fracture zone and types of fracture.

Conclusions

There are many studies about clinical cardiac findings in patients with sternal fractures; however, these findings were not evaluated according to the zone of fracture or type of fracture (displaced/non-displaced). In our study, we aimed

to determine the cardiac findings between patients with fracture on different sternal zones and fracture types. We found that abnormal echocardiography findings were more frequent in patients with sternal fracture on the manubrium and those with displaced fracture. Further prospective studies with larger cohorts are needed to evaluate the long-term outcomes of the patients with sternal fracture according to different fracture zones and fracture types.

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REFERENCES

1. Canevelli M, Lucchini F, Quarata F, Bruno G, Cesari M. Nutrition and Dementia: Evidence for Preventive Approaches? *Nutrients* 2016;8:144.
2. Ziegler DW, Agarwal NN. The morbidity and mortality of rib fractures. *J Trauma* 1994;37:975-9. [CrossRef]
3. Besson A, Saegesser F. *Color Atlas of Chest Trauma and Associated Injuries*. Vol 1. NJ:Medical Economics; 1983. p. 9.
4. Kaewlai R, Avery LL, Asrani AV, Novelline RA. Multidetector CT of blunt thoracic trauma. *Radiographics* 2008;28:1555-70. [CrossRef]
5. Demirhan R, Onan B, Oz K, Halezeroglu S. Comprehensive analysis of 4205 patients with chest trauma: a 10-year experience. *Interact Cardiovasc Thorac Surg* 2009;9:450-3. [CrossRef]
6. Cangir A, Nadir A, Akal M, Kutlay H, Özdemir N, Güngör A, et al. Thoracic trauma: Analysis of 532 patients. *Turk J Trau* 2000;6:100-5.
7. Monaco M, Mondello B, Monaco F, Vasta I, Perrone O, Micali V, et al. Misunderstood cardiac involvement with heart impairment in traumatic sternal fracture: an enzyme-guided evaluation. *G Chir* 2009;30:117-20.
8. Rashid MA, Ortenwall P, Wikström T. Cardiovascular injuries associated with sternal fractures. *Eur J Surg* 2001;167:243-8. [CrossRef]
9. Buckman R, Trooskin SZ, Flancbaum L, Chandler J. The significance of stable patients with sternal fractures. *Surg Gynecol Obstet* 1987;164:261-5.
10. Wojcik JB, Morgan AS. Sternal fractures-the natural history. *Ann Emerg Med* 1988;17:912-4. [CrossRef]
11. Rambaud G, Desachy A, François B, Allot V, Cornu E, Vignon P. Extrapericardial cardiac tamponade caused by traumatic retrosternal-hematoma. *J Cardiovasc Surg* 2001;42:621-4.
12. Velissaris T, Tang AT, Patel A, Khallifa K, Weeden DF. Traumatic sternal fracture: outcome following admission to a Thoracic Surgical Unit. *Injury* 2003;34:924-7. [CrossRef]
13. Perez MR, Rodriguez RM, Baumann BM, Langdorf MI, Anglin D, Bradley RN, et al. Sternal fracture in the age of pan-scan. *Injury* 2015;46:1324-7. [CrossRef]
14. Skinner DL, Laing GL, Rodseth RN, Ryan L, Hardcastle TC, Muckart DJ. Blunt cardiac injury in critically ill trauma patients: a single centre experience. *Injury* 2015;46:66-70. [CrossRef]

15. Athanassiadi K, Gerazounis M, Moustardas M, Metaxas E. Sternal fractures: retrospective analysis of 100 cases. *World J Surg* 2002;26:1243–6.
16. Knobloch K, Wagner S, Haasper C, Probst C, Krettek C, Otte D, et al. Sternal fractures occur most often in old cars to seat-belted drivers without any airbag often with concomitant spinal injuries: clinical findings and technical collision variables among 42,055 crash victims. *Ann Thorac Surg* 2006;82:444–50. [CrossRef]
17. Burnside N, McManus K. Blunt thoracic trauma. *Surgery (Oxford)* 2014;32:254–60. [CrossRef]
18. Johnson I, Branfoot T. Sternal fracture-a modern review. *Arch Emerg Med* 1993;10:24–8. [CrossRef]
19. Wiener Y, Achiliev B, Karni T, Halevi A. Echocardiogram in sternal fracture. *Am J Emerg Med* 2001;19:403–5. [CrossRef]
20. Sadaba JR, Oswal D, Munsch CM. Management of isolated sternal fractures: determining the risk of blunt cardiac injury. *Ann R Coll Surg Engl* 2000;82:162–6.
21. Wedde TB, Quinlan JF, Khan A, Khan HJ, Cunningham FO, McGrath JP. Fractures of the sternum: the influence of non-invasive cardiac monitoring on management. *Arch Orthop Trauma Surg* 2007;127:121–3.
22. von Garrel T, Ince A, Junge A, Schnabel M, Bahrs C. The sternal fracture: radiographic analysis of 200 fractures with special reference to concomitant injuries. *J Trauma* 2004;57:837–44. [CrossRef]

ORİJİNAL ÇALIŞMA - ÖZET

Toraks travmasına bağlı sternal kırıkların kardiyak bulguları: Beş yıllık geriye dönük bir çalışma

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AMAÇ: Bu çalışmanın temel amacı; torasik travmalı hastalarda sternal kırık sıklığını, farklı sternal zonlarda kırığı olan ve deplase ve non-deplase sternal kırıklı hastalardaki, cerrahi gereksinim, kardiyak bulgular ve tedavi sürecindeki farklılıkları belirlemektir.

GEREÇ VE YÖNTEM: Ocak 2011–Aralık 2015 tarihleri arasında bir devlet hastanesine başvuran torasik travmaya bağlı sternal kırıklı olguların verileri analiz edildi. Hastaların verileri, demografik özellikler, travma özellikleri, klinik bulguları ve tedavi yöntemlerini içermektedir.

BULGULAR: Çalışma süresince başvuran 2764 torasik travmalı hastanın 72'sinde (%2.6) sternal kırık saptandı. Hastaların medyan yaşları 52 (ÇAA: 61–38) iken, ağırlığı erkekler oluşturdu (kadın/erkek: 18/54). Sternal kırık olgularının en sık üç nedeni motorlu taşıt kazası, düşme ve iş kazasıydı. Olguların 15'inde deplase kırık olduğu bulundu. Anormal ekokardiyografi bulguları, manubrium kırıklı olgularda, korpus kırıklı olgulara göre istatistiksel olarak anlamlı şekilde daha fazla idi. Korpus kırıklı hastalarda, manubrium kırıklılara oranla istatistiksel olarak daha az sıklıkta cerrahi ihtiyacı gelişti. Ayrıca, deplase kırığı olan ve olmayan hastalar arasında cerrahi girişim gereksinimlerine göre istatistiksel olarak anlamlı farklılık vardı ($p<0.005$).

TARTIŞMA: Manubriumda görülen ve deplase sternal kırıklarda anormal ekokardiyografi bulguları daha fazla sıklıkta görülmektedir.

Anahtar sözcükler: Kardiyak bulgular; sternal kırık; torasik travma.

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