



Sternal Fractures: Emergency Management and Radiologic Evaluation

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Abstract

Background: Sternal fractures are uncommon but clinically important injuries that typically result from blunt anterior chest trauma, most often associated with high-energy deceleration events such as motor vehicle collisions. Although once considered markers of severe trauma, advances in imaging and trauma care have improved their detection and management. The main clinical concern lies in the high frequency of associated thoracic, pulmonary, and cardiac injuries rather than the fracture itself.

Aim: This article aims to review the etiology, epidemiology, pathophysiology, clinical presentation, diagnostic strategies, and management approaches of sternal fractures in the emergency setting, with an emphasis on radiologic evaluation and multidisciplinary care.

Methods: A narrative review approach was used, synthesizing current evidence from trauma and emergency medicine literature. The discussion integrates clinical assessment, imaging modalities—including radiography, computed tomography, and ultrasound—and principles of emergency and trauma management guided by Advanced Trauma Life Support protocols.

Results: Sternal fractures most frequently result from blunt trauma, particularly motor vehicle collisions, but may also arise from insufficiency or stress mechanisms. Lateral chest radiographs and computed tomography are critical for diagnosis, while cardiac monitoring and biomarkers are essential to detect associated myocardial injury. Most isolated fractures are managed conservatively with analgesia and respiratory support, whereas surgical fixation is reserved for displaced or unstable injuries. Prognosis is generally favorable in isolated cases but worsens significantly with associated injuries.

Conclusion: Sternal fractures require systematic evaluation due to their strong association with life-threatening thoracic injuries. Early diagnosis, appropriate imaging, and multidisciplinary management are key to optimizing outcomes.

Keywords: Sternal fracture; Blunt chest trauma; Emergency management; Computed tomography; Cardiac injury; Radiologic evaluation

Introduction

Sternal fractures predominantly arise from blunt trauma to the anterior chest wall, commonly occurring during high-impact deceleration events such as motor vehicle collisions, with reported incidence rates ranging from 3% to 6.8% in such contexts. Additional etiologies include athletic trauma, accidental falls, and interpersonal assaults,

which account for a smaller proportion of cases. Accurate diagnosis is typically established through imaging modalities, with lateral chest radiography serving as the initial assessment tool, while computed tomography (CT) of the thorax provides superior sensitivity, particularly for detecting complex or subtle fractures. Sternal fractures are clinically significant due to their frequent association with

concomitant injuries, including thoracic, cardiac, and pulmonary trauma, which may influence both prognosis and management strategies. The clinical course and disposition of patients sustaining sternal fractures are determined by multiple considerations, encompassing the presence and severity of associated injuries, underlying comorbid conditions, and the adequacy of pain control measures. Effective assessment and management necessitate an integrated approach to evaluate both the fracture and potential secondary complications, ensuring optimal patient outcomes [1][2].

Etiology

Traumatic sternal fractures are relatively uncommon but clinically significant, occurring in approximately 8% of patients who sustain blunt chest trauma and in up to 18% of polytrauma cases involving thoracic injuries. Penetrating injuries to the sternum are rare. The majority of sternal fractures result from blunt anterior chest-wall trauma, particularly deceleration injuries sustained during high-impact events. Motor vehicle collisions remain the principal mechanism, accounting for approximately 68% of sternal fractures, followed by falls and motorcycle accidents, each contributing nearly 8% of cases. Pedestrian-versus-vehicle collisions and cycling accidents represent smaller proportions, estimated at 3.4% and 1.4% respectively. The widespread implementation of seat belt legislation, especially those requiring shoulder restraints, has paradoxically contributed to an increase in sternal fractures, as the anterior chest is compressed against the seat belt during sudden deceleration [3]. Beyond traumatic causes, sternal insufficiency fractures occur in the context of weakened thoracic structures, often associated with advanced osteoporosis. Pronounced thoracic kyphosis resulting from multiple vertebral compression fractures increases mechanical stress on the sternum, predisposing patients to insufficiency fractures. The sternum, in conjunction with the ribs, constitutes the fourth column of structural support for the thoracic spine. Displaced sternal fractures in this setting may indicate significant flexion-distraction injuries to the spine and are associated with an elevated risk of deformity [4]. Populations at increased risk include postmenopausal women, elderly patients, and those receiving long-term corticosteroid therapy, all of whom are more prone to osteoporotic fractures. Additionally, sternal stress fractures can develop from repetitive upper body activities. Sports that involve frequent and forceful movements of the upper extremities, such as weightlifting, golf, and rowing, have been associated with microtrauma to the sternum over time, culminating in stress fractures. These fractures typically result from chronic, cumulative mechanical strain rather than acute trauma and are most frequently observed in athletes or individuals engaging in repetitive strenuous

activity [5]. The etiology of sternal fractures is therefore multifactorial, encompassing acute blunt trauma, chronic insufficiency related to bone fragility, and repetitive mechanical stress. Understanding the underlying cause is essential, as it informs both the diagnostic approach and subsequent management strategies. Trauma-related fractures require assessment for associated thoracic and mediastinal injuries, whereas insufficiency and stress fractures necessitate evaluation of underlying bone health, spinal alignment, and risk factors for future skeletal injury. Recognizing these etiologic patterns allows clinicians to provide targeted interventions, optimize patient outcomes, and reduce the risk of recurrent fractures or long-term complications.

Epidemiology

Sternal fractures occur in approximately 3% to 6.8% of patients involved in motor vehicle collisions. The introduction of seat belt legislation mandating shoulder restraints has paradoxically increased the incidence of these fractures, as the anterior chest is compressed against the restraint during sudden deceleration. Furthermore, the routine use of computed tomography (CT) for trauma evaluation has contributed to the more frequent identification of minor, previously undetected sternal fractures, enhancing reported incidence rates. The clinical significance of sternal fractures is closely tied to the presence of associated injuries rather than the fracture itself. Isolated sternal fractures are generally associated with lower rates of cardiorespiratory compromise and demonstrate more favorable trauma assessment scores compared to fractures occurring in the context of polytrauma [4]. Mechanistically, sternal fractures frequently result from the chest striking the steering wheel during vehicular collisions, particularly in older vehicles without airbag deployment. Epidemiologic data suggest that these fractures occur slightly more often in women than men. Age is an important determinant, with older patients demonstrating a higher prevalence of sternal fractures. This pattern is likely due to reduced elasticity of the chest wall in older individuals, which increases susceptibility to anterior thoracic injury. In contrast, younger patients have more compliant chest walls that absorb kinetic energy more effectively, reducing the likelihood of sternal fracture but increasing the risk of intrathoracic injuries [6][7]. Understanding these demographic and mechanistic patterns is essential for trauma assessment, patient risk stratification, and the identification of potential associated injuries.

Pathophysiology

Sternal fractures predominantly arise from blunt anterior chest trauma, most commonly involving the sternal body or manubrium. These fractures are frequently associated with significant thoracic organ injuries, which can substantially increase morbidity and, in severe cases, result in

mortality. Pulmonary complications are among the most prevalent, including pneumothorax, hemothorax, pulmonary contusion, and tracheobronchial injury. Such injuries may manifest clinically with dyspnea, hypoxia, or severe respiratory distress, and often require immediate resuscitative measures. Prompt recognition and management of these pulmonary complications are essential to prevent life-threatening outcomes [8]. In addition to pulmonary involvement, sternal fractures can precipitate critical cardiovascular conditions. Dogrul et al. identified six urgent conditions in patients with chest trauma that necessitate immediate assessment and intervention: airway obstruction, tension pneumothorax, open pneumothorax, massive hemothorax, flail chest, and pericardial tamponade [9]. Cardiac injury may also manifest as myocardial infarction secondary to blunt trauma, arising from mechanisms such as coronary artery dissection, acute plaque rupture, coronary thrombosis, cardiac contusion, or the formation of coronary artery fistulas. Management of traumatic myocardial infarction requires individualized approaches, which may include coronary artery bypass grafting, percutaneous coronary intervention with or without stent placement, aspiration thrombectomy, or conservative medical therapy depending on the severity and location of the lesion [10]. The pathophysiology of sternal fractures is therefore closely linked to the energy transfer during trauma and the susceptibility of the anterior chest wall. The sternum acts as a structural barrier protecting thoracic organs, but its fracture can directly compromise underlying structures, particularly the lungs and heart. The degree of displacement, fracture location, and the presence of concomitant thoracic injuries are key determinants of clinical severity. Consequently, sternal fractures are rarely isolated injuries, and their management must address both the skeletal disruption and potential life-threatening visceral complications. Understanding these pathophysiological mechanisms is essential for timely diagnosis, risk stratification, and the implementation of appropriate therapeutic interventions in emergency and trauma settings.

History and Physical

Sternal fractures most commonly result from blunt anterior chest trauma and deceleration injuries, with motor vehicle collisions representing the predominant cause. Other contributing factors include athletic injuries, falls, and assaults. Patients typically present with localized anterior chest pain, which may intensify with deep inspiration, coughing, or movement of the upper body. Up to 20% of patients may report shortness of breath secondary to pain or associated thoracic injuries. In cases of sternal stress fractures or acute insufficiency fractures, the pain may be more diffuse and nonspecific, often mimicking other cardiopulmonary or musculoskeletal conditions, particularly in the absence of an overt

traumatic event. Physical examination frequently reveals point tenderness directly over the site of the fracture. Approximately half of patients exhibit associated soft tissue swelling, ecchymoses, or palpable deformity at the anterior chest wall. Crepitus may also be detected on palpation in cases of displaced fractures. Comprehensive assessment is essential to identify concomitant injuries, which are common due to the high-energy mechanisms involved. These include rib fractures, flail chest, sternoclavicular joint dislocation, pneumothorax, hemothorax, cardiac tamponade, myocardial contusion, pulmonary contusion, intra-abdominal trauma, and spinal compression fractures. A thorough history and detailed physical examination are therefore critical not only for identifying the sternal fracture but also for recognizing potentially life-threatening associated injuries that may necessitate urgent intervention [11].

Evaluation

The initial evaluation of suspected sternal fractures typically begins with chest radiography. Standard anteroposterior (AP) radiographs demonstrate limited sensitivity, detecting only approximately 50% of sternal fractures due to the predominantly transverse orientation of these injuries. Lateral radiographs substantially increase diagnostic accuracy, as most sternal fractures occur in the sagittal plane and any displacement is better visualized from this perspective [2][12]. Radiography, therefore, remains a practical first-line imaging modality, particularly in stable patients with isolated chest trauma. Computed tomography (CT) scans provide a more detailed assessment, especially in patients with a high index of suspicion for sternal injury or with inconclusive radiographs. Axial CT images may occasionally fail to identify transverse fractures, whereas spiral CT offers greater sensitivity and is increasingly utilized for definitive evaluation. Beyond fracture detection, CT imaging enables comprehensive assessment of associated thoracic injuries, including pulmonary contusions, pneumothorax, hemothorax, and mediastinal or vascular trauma, which are frequently present in high-energy mechanisms of injury. Despite its advantages, no universally accepted gold standard exists for imaging sternal fractures. Ultrasonography has emerged as a rapid, bedside alternative with sensitivity equal to or exceeding plain radiography. Point-of-care ultrasound facilitates immediate fracture detection, expediting clinical decision-making. However, its utility is dependent on operator expertise, and inter-operator variability can limit diagnostic consistency.

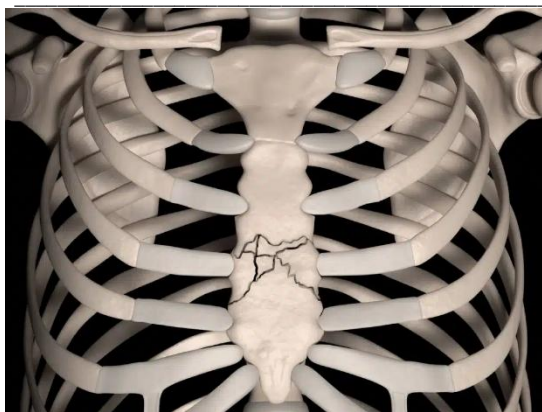


Fig. 1: Sternal Fracture.

Given the close anatomical relationship of the sternum to the heart, cardiac monitoring is essential for all patients presenting with sternal fractures in the emergency setting. Continuous pulse oximetry and electrocardiographic (ECG) evaluation are recommended to identify arrhythmias, conduction abnormalities, sinus tachycardia, and ST-segment changes indicative of myocardial contusion. Measurement of serum cardiac biomarkers, particularly troponin, provides additional evidence of myocardial injury. Echocardiography serves a complementary role, offering direct visualization of wall motion abnormalities and enabling assessment of myocardial integrity following blunt chest trauma. In sum, evaluation of sternal fractures necessitates a multimodal approach combining imaging, cardiac assessment, and clinical monitoring. The choice of diagnostic modality should be guided by the mechanism of injury, patient stability, and the potential for associated thoracic or cardiac injuries, ensuring accurate diagnosis and timely management of both the fracture and any concurrent complications.

Treatment / Management

The management of sternal fractures requires a structured, evidence-based approach, prioritizing patient stabilization and the treatment of potentially life-threatening injuries. Initial management should conform to Advanced Trauma Life Support (ATLS) protocols, ensuring that airway, breathing, and circulation are promptly assessed and secured. The primary survey focuses on identifying critical injuries that may accompany sternal fractures, including tension pneumothorax, hemothorax, cardiac tamponade, and flail chest. Immediate intervention for these conditions is essential to prevent mortality. Once the patient is stabilized, a thorough secondary survey is performed to detect and address additional thoracic injuries such as rib fractures, pulmonary contusions, and blunt myocardial injury. These associated injuries are common in sternal trauma due to the energy transfer involved in blunt anterior chest-wall impacts [13][14]. Surgical intervention is reserved for specific, complex cases. Although rare, injuries to the tracheobronchial tree, esophagus,

diaphragm, heart, or aorta may occur in high-energy trauma and frequently necessitate operative repair. Surgical management may also be indicated for severely displaced or unstable sternal fractures that cannot achieve adequate alignment through conservative measures [15]. Cardiac monitoring is essential in all patients with sternal fractures to detect myocardial contusion or arrhythmias. Electrocardiography and serial measurement of cardiac biomarkers, particularly troponin, assist in identifying myocardial injury. Patients exhibiting evidence of cardiac involvement, hemodynamic instability, or intrathoracic complications require hospital admission for observation and intervention. Older adults warrant special attention due to an increased risk of respiratory compromise and slower functional recovery.

For isolated, uncomplicated sternal fractures, conservative management is the standard of care. Adequate analgesia forms the cornerstone of treatment and facilitates adequate ventilation, which reduces the risk of secondary pulmonary complications such as atelectasis or pneumonia. Nonsteroidal anti-inflammatory drugs and opioid-based regimens may be used judiciously based on patient comorbidities and pain severity. Patients should be instructed to perform deep breathing exercises and, when feasible, incentive spirometry to maintain lung expansion and prevent hypoventilation. Hospitalization is not typically required for patients without associated injuries or clinical concerns; early outpatient follow-up within 24 hours is recommended to assess pain control, respiratory function, and fracture stability. The natural course of sternal fractures is generally favorable, with most isolated injuries healing spontaneously over an average period of approximately 10 weeks. During this time, patients should be counseled on activity modification, avoiding heavy lifting or strenuous upper body movements that may exacerbate pain or disrupt healing. Surgical fixation, although infrequently required, can provide significant benefit in patients with severe displacement, persistent pain, or instability that compromises respiratory mechanics. Operative approaches may involve rigid plate fixation or wire cerclage to restore anatomical alignment and enhance functional recovery. In conclusion, the management of sternal fractures is predominantly conservative, emphasizing early stabilization, adequate analgesia, and pulmonary care. Prompt recognition and treatment of associated thoracic injuries are crucial, and surgical intervention is reserved for complex, unstable, or high-risk fractures. A multidisciplinary approach, including emergency physicians, trauma surgeons, radiologists, and nursing staff, ensures comprehensive care, minimizes complications, and promotes optimal recovery. Patient education on symptom monitoring, activity restrictions, and follow-up adherence further

enhances outcomes and supports the safe resolution of sternal fractures [13][14].

Differential Diagnosis

The evaluation of an acute sternal injury necessitates a careful consideration of a wide array of differential diagnoses due to the potential for associated or mimicking injuries. Rib fractures are commonly encountered alongside sternal fractures and may present with localized pain, crepitus, or respiratory compromise. Flail chest, characterized by multiple contiguous rib fractures with paradoxical chest wall motion, can similarly manifest with chest pain and impaired ventilation, necessitating urgent recognition and intervention. Sternoclavicular dislocations, although less frequent, may produce anterior chest pain and deformity, often requiring imaging to distinguish from sternal fractures. Intrathoracic complications such as pneumothorax and hemothorax must be actively considered, as both conditions can result in dyspnea, hypoxia, and hemodynamic instability. Cardiac injuries, including myocardial contusion and cardiac tamponade, may present with hypotension, arrhythmias, or chest discomfort and require electrocardiographic and echocardiographic assessment to confirm. Pulmonary contusions can mimic sternal fracture pain while contributing to hypoxemia and respiratory distress. In polytrauma patients, intra-abdominal injuries and spinal compression fractures may coexist, presenting with overlapping symptoms that can obscure the diagnosis of a sternal fracture. Accurate differentiation among these conditions relies on a combination of careful clinical assessment, detailed history regarding the mechanism of injury, and appropriate imaging studies, including chest radiographs, computed tomography, and ultrasonography when indicated. Identifying and excluding these alternative or associated injuries is critical, as management strategies vary widely and may include surgical intervention, hemodynamic stabilization, or conservative monitoring. Failure to recognize concurrent injuries can lead to delayed treatment, increased morbidity, and adverse outcomes, highlighting the importance of a systematic, multidisciplinary approach in the evaluation of patients with suspected sternal trauma [14].

Prognosis

The prognosis for patients sustaining sternal fractures is generally favorable, particularly in cases of isolated injury. Hospitalized patients with sternal fractures demonstrate a low 30-day mortality rate of approximately 8%, indicating that, although the mechanism of injury may be severe, the fractures themselves rarely result in fatal outcomes [11]. Isolated sternal fractures carry an even more optimistic outlook, with an overall mortality rate reported at 0.7%. Recovery is typically complete within an average period of 10 weeks, with most patients experiencing resolution of pain and

restoration of normal thoracic function without long-term sequelae. In rare instances, persistent pain or nonunion may necessitate surgical fixation to ensure stability and alleviate discomfort. However, the prognosis is heavily influenced by the presence of concomitant injuries. Up to two-thirds of sternal fractures occur in the context of additional thoracic or systemic trauma, including rib fractures, pulmonary contusions, myocardial contusions, or intra-abdominal injuries. In these scenarios, mortality increases substantially, with reported rates ranging from 25% to 45%, reflecting the severity of the associated injuries rather than the sternal fracture itself. Consequently, patient outcomes are closely tied to the comprehensive evaluation and management of these concurrent injuries. Prompt identification and treatment of associated trauma, along with appropriate analgesia, respiratory support, and monitoring, remain critical to improving survival and functional recovery. Overall, while isolated sternal fractures are associated with excellent outcomes, vigilance for additional injuries is essential in optimizing prognosis in polytrauma patients [11].

Complications

Complications arising from sternal fractures are often closely linked to associated injuries and the severity of the fracture. Displaced or unstable sternal fractures may compromise the structural integrity of the anterior chest wall, increasing susceptibility to pulmonary complications, pericardial effusions, rib fractures, and spinal compression fractures. Persistent chest pain is common, often lasting 8 to 12 weeks, and can impede deep breathing and effective coughing, predisposing patients to atelectasis, pneumonia, and other respiratory complications. Delayed or impaired healing is a concern in specific populations. Older adults, patients with osteoporosis, those receiving prolonged corticosteroid therapy, and individuals with diabetes exhibit increased risk of sternal nonunion, false joint formation, or malalignment resulting in overlap deformities. Although rare, these conditions may necessitate delayed surgical intervention to restore chest wall stability and alleviate chronic pain. Infectious complications, although uncommon, can be severe. Osteomyelitis, sternal abscesses, and mediastinitis have been reported, particularly in patients with large hematomas, intravenous drug use, or coexisting staphylococcal infections. The risk of such infections is heightened in immunocompromised patients and those with prolonged hospitalization or invasive procedures. Early recognition and management of these complications are essential to minimize morbidity. Overall, while most sternal fractures heal uneventfully with conservative care, awareness of potential complications and close monitoring of high-risk patients remain critical for optimal outcomes [11][12].

Patient Education

Effective patient education is a critical component of managing sternal fractures and optimizing recovery outcomes. Clinical staff should provide a clear explanation of the mechanism of injury, highlighting how blunt trauma, deceleration forces, or direct impacts to the anterior chest wall result in sternal fractures. Patients should be informed about the typical course of healing, expected duration of pain, and the potential for associated complications, including pulmonary or cardiac involvement. Clinicians must emphasize adherence to prescribed medications and therapy regimens. For patients receiving analgesics, instructions should cover proper dosing schedules, the importance of avoiding medications that may exacerbate risk, and safe use of adjunct therapies, such as anti-inflammatory agents or muscle relaxants. For post-surgical patients, guidance should include wound care, recognition of signs of infection, activity restrictions, and the importance of follow-up appointments to monitor bone healing and functional recovery. Lifestyle modifications should be discussed to promote comfort and prevent complications. Patients should be encouraged to use supportive pillows or modified sleeping positions to reduce anterior chest wall strain. Gradual resumption of daily activities should be recommended, with avoidance of heavy lifting, high-impact exercises, or strenuous upper body movements until the clinician confirms sufficient healing. Deep breathing exercises should be encouraged to prevent pulmonary complications such as atelectasis or pneumonia. Additionally, patients should be instructed on red-flag symptoms that necessitate immediate medical attention, including worsening chest pain, dyspnea, palpitations, or fever. Clear guidance on when to contact healthcare providers ensures timely intervention and reduces the risk of preventable complications. By combining education on injury mechanisms, therapeutic compliance, lifestyle adjustments, and warning signs, healthcare teams empower patients to actively participate in their recovery, improving outcomes and minimizing long-term morbidity [14].

Enhancing Healthcare Team Outcomes

The management of sternal fractures requires a coordinated, multidisciplinary approach to ensure optimal patient outcomes. Patients often present to emergency departments following blunt chest trauma or deceleration injuries, and a subset may require intensive care unit (ICU) monitoring due to associated cardiopulmonary complications. Nurses play a central role in the initial assessment, continuous monitoring, and patient education, including the importance of pain management, respiratory exercises, and activity modifications. Their ability to recognize early signs of complications, such as pneumothorax, hemothorax, or myocardial contusion, directly impacts patient

safety and recovery trajectories. Respiratory therapists are integral to the healthcare team, facilitating chest physiotherapy to maintain lung expansion and prevent pulmonary complications, including atelectasis and pneumonia. Early mobilization and guided breathing exercises contribute to improved ventilation and oxygenation, particularly in older patients or those with comorbidities that compromise pulmonary function. Pharmacists also support care by ensuring safe analgesic regimens, optimizing medication adherence, and monitoring for potential drug interactions, particularly in polypharmacy cases. Most patients with sternal fractures experience favorable outcomes, with healing and functional recovery typically occurring within 4 to 6 weeks. Conservative management is appropriate for isolated, stable fractures and includes pain control, activity modification, and monitoring for delayed complications. Surgical intervention is reserved for displaced, unstable fractures, or cases complicated by nonunion or persistent pain. Older adults and patients with osteoporotic bone may require extended rehabilitation periods and structured physical therapy programs to restore upper body strength, improve posture, and prevent musculoskeletal deconditioning. Interprofessional collaboration enhances both acute management and long-term recovery. Clear communication between physicians, nurses, respiratory therapists, physical therapists, and pharmacists ensures that care plans are individualized and responsive to patient needs. Regular multidisciplinary meetings and shared decision-making allow the healthcare team to anticipate complications, adjust therapy protocols, and support patient education. By integrating clinical expertise across disciplines, the healthcare team can reduce recovery time, prevent secondary complications, and improve overall patient satisfaction, particularly for high-risk populations. This comprehensive, team-based approach maximizes functional outcomes and strengthens the delivery of patient-centered care for individuals with sternal fractures [14].

Conclusion:

Sternal fractures, while relatively uncommon, represent an important diagnostic and management challenge in emergency and trauma medicine due to their frequent association with serious thoracic and cardiovascular injuries. The fracture itself is rarely life-threatening; however, the mechanisms responsible for sternal injury often transfer significant kinetic energy to the chest, placing underlying structures such as the lungs, heart, and mediastinum at risk. Consequently, the clinical importance of sternal fractures lies in the identification and management of accompanying injuries rather than the isolated bone disruption. Advances in imaging techniques, particularly computed tomography, have improved diagnostic

accuracy and allowed earlier recognition of both fractures and associated complications. Cardiac monitoring, electrocardiography, and biomarker assessment remain essential components of evaluation given the close anatomical relationship between the sternum and the heart. Most isolated sternal fractures respond well to conservative treatment, emphasizing adequate analgesia, respiratory support, and early mobilization. Surgical intervention remains limited to select cases involving instability, displacement, or nonunion. Overall, outcomes are favorable when sternal fractures are promptly recognized and systematically evaluated within a multidisciplinary framework. Adherence to trauma assessment protocols, combined with patient education and follow-up, plays a vital role in minimizing complications, reducing morbidity, and ensuring full functional recovery.

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