EVALUATION OF COMMON FRACTURES DETECTED ON CHEST RADIOGRAPH OF ROAD TRAFFIC ACCIDENT PATIENTS IN BENIN CITY

BY

ANOSIKE SHALOM IJEOMA

BMS2101784

A PROJECT PROPOSAL SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) IN RADIOGRAPHY

DEPARTMENT OF RADIOGRAPHY

SCHOOL OF BASIC MEDICAL SCIENCE

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OCTOBER 2025

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SUPERVISED BY

DR. UCHECHUKWU NWADIKE

OCTOBER 2025

CERTIFICATION

This is to certify the project on EVALUATION OF COMMON FRACTURES DETECTED ON CHEST RADIOGRAPH OF ROAD TRAFFIC ACCIDENT PATIENTS IN BENIN CITY written by ANOSHIKE SHALOM IJEOMA with matriculation number BMS2101784 in partial fulfillment of the Bachelor of Radiography Degree (B.Rad) in the DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN.

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(Head of Department) Date

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EXTERNAL EXAMINER Date

APPROVAL

Project Title: EVALUATION OF COMMON FRACTURES DETECTED ON CHEST RADIOGRAPH OF ROAD TRAFFIC ACCIDENT PATIENTS IN BENIN CITY

Supervisor's Name: DR. U.I. NWADIKE Signature and Date ....

Head of Department: Mrs. F. O. Igbinedion Signature and Date ....

DEDICATION

I dedicate this project work to God almighty the ultimate giver of life, knowledge and wisdom.

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My sincere gratitude goes to God almighty for the wisdom, strength and enablement he made available for me whilst carrying out this Project work. My heartfelt gratitude goes to my parents Chief Dr. Sir & Lady Tim Nkiru Anosike who contributed immensely towards my education, my lovely and ever supportive siblings for their constant love and encouragement. I also genuinely appreciate my dearest friend Stanley Nwachukwu for his endless love and support towards this project. My deepest appreciation goes to my supervisor Dr. Uchechukwu Nwadike for his selfless help, guidance and contributions throughout the process of writing this project. Also my gratitude goes to my HOD Mrs. F.O. Igbinedion, and my lecturers Dr. C. Okungbowa, Mrs. E. Okeh, Mr. C.V. Egbukichi and Mr. C.V. Mbiaku for their tangible contributions, words of wisdom and painstaking efforts in making me better than they met me, through the means of education. May God strengthen and bless them all in their endeavours.

To my friends Zulfah Abdulahi, Odoh Henry, Osama, Awele, Peace, Isi, my senior colleges who were always there for me including Rad. Yamah Princewill and the rest thank you for your friendship, love, motivation and support.

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ABSTRACT

Background: Chest X-ray (CXR) is the most widely requested imaging investigation for the immediate evaluation of patients involved in road traffic accidents (RTAs). A single posteroanterior (PA) chest radiograph can rapidly identify fractures of the rib cage as well as pulmonary and pleural pathologies such as pneumothorax, hemothorax, and pulmonary contusion, which are critical for early clinical decision-making.

Objective: To identify common fractures and other pathologies on chest radiographs of road traffic accident patients in the University of Benin Teaching Hospital (UBTH).

Methods: A retrospective descriptive cross-sectional study design was used. Data were collected by reviewing chest radiographs and radiological reports of 184 patients involved in road traffic accidents between January 2022 and December 2024. The distribution of chest wall fractures, fracture patterns, and associated thoracic pathologies was analyzed.

Results: Middle rib fractures (4th–8th ribs) were the most common, accounting for 73.5% of cases, followed by upper rib fractures (29.7%) and lower rib fractures (29.2%). Sternal fractures were identified in 10.8% of patients, clavicular fractures in 13.5%, and scapular fractures in 6.5%. Non-displaced fractures were the predominant fracture type, while displaced, comminuted, and segmental fractures were also observed. Associated thoracic pathologies included pneumothorax (22.7%), hemothorax (18.9%), and pulmonary contusion (15.1%), with their incidence increasing significantly in patients with multiple or complex fracture patterns.

Conclusion: Rib fractures were the most frequently identified pathology on chest radiographs of RTA patients, followed in descending order by pneumothorax, hemothorax, pulmonary contusion, clavicular fractures, sternal fractures, and scapular fractures. The distribution and complexity of fractures on chest X-ray were strong indicators of associated thoracic complications, reinforcing the value of conventional chest radiography in trauma evaluation at UBTH.

Keywords: Chest X-ray, rib fractures, pneumothorax, hemothorax, road traffic accidents.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Chest X-ray is the most widely used imaging modality in the immediate evaluation of patients that are affected by road traffic accidents (RTAs) A single AP chest X-ray can swiftly reveal fractures of the ribs, sternum, clavicle, and scapula, as well secondary findings like pneumothorax, hemothoxax, contusion that aid life saving interventions ((Ho & Gutierrez, 2009; Lewis et al, 2021). In addition, axial skeleton fractures, diaphragmatic and aortic injuries, subcutaneous and mediastinal emphysema, and tube and catheter malposition can be assessed.

A rapid modality with a high diagnostic yield, the CXR is essential for the first evaluation of trauma patients. The patient is exposed to very little radiation (Berrington & Darby, 2004). It is standard procedure for the trauma team, often consisting of on-call residents, to evaluate the CXR performed in the emergency room. Despite having sufficient interpretive abilities, the trauma team frequently faces challenging circumstances and does not enjoy the luxury of extended interpretation timeframes. When a trauma team interprets CXRs, they may overlook occult pneumothoraces in as many as 76% of all critically injured patients (Ball et al., 2009).

Fractures are defined as breaks or disruptions in the continuity of bone, typically resulting from trauma, excessive force, or pathological weakening (Court-Brown & Caesar, 2006). In the context of thoracic trauma, fractures of the ribs, clavicle, sternum, and scapula are particularly significant because they can compromise the integrity of the chest wall and lead to life-threatening complications such as pneumothorax, hemothorax, and injury to underlying organs (Mirvis & Shanmuganathan, 2007). Early and accurate detection of these fractures on imaging, especially chest radiography, is crucial for guiding timely interventions and reducing morbidity.

If a specialised trauma radiologist could identify particular injuries that the trauma team missed during a second read, it might potentially improve the diagnostic performance of CXR. The patient should ideally be sitting erect and fully inspired when taking chest radiographs in the posteroanterior and lateral views. However, imaging trauma patients frequently requires them to lie down, which makes it more difficult to see and locate injuries. It is not possible to differentiate between underlying viscera and overlying soft-tissue and bone lesions on single-view anteroposterior radiographs. Because the x-ray beam is orientated perpendicularly, air-fluid levels are invisible. Pseudocardiomegaly and apparent increases in pulmonary vascularity can result from inadequate inspiratory effort and magnification effects.

However, when considered in light of these constraints, the chest radiograph can be a very useful instrument that offers a wealth of information about several organ systems. Thoracic polytrauma can present in a variety of ways, contingent on the organ system or systems involved as well as the mode of injury. Closed, nonpenetrating physical trauma brought on by impact injuries or other compressive and shear forces is referred to as blunt trauma. Deceleration injuries (car crashes, falls) and blunt force injuries (physical assaults, crush injuries) are frequent instances. Bone fractures, organ laceration or rupture, abrasions, and contusions are among the complications (Gavelli et al., 2002; Thoongsuwan et al., 2005; Zinc et al., 2000; Wicky et al. 2000).

Penetrating trauma, on the other hand, is when an object enters the body via the skin. The object's trajectory and momentum dictate the extent of the injury. Hand-propelled low-velocity objects, like knives, only inflict harm on areas that come into direct contact. Bullets and other shrapnel are examples of higher-velocity projectiles that, as they enter the body, produce pressure waves that push away nearby tissue. In addition to providing cavitation injury to a vast surrounding area, this hurts regions in direct contact [Gaveli et al., 2000; Shanmuganathan et al., 2006; LeBlang and Dolich, 2000].

In areas like Benin where there are almost frequent events of RTA, the chest X-ray can be utilized in both screening and triaging patients. Despite the ubiquity, we lack a clear picture of which fractures commonly affect RTA victims within the area and wether a particular fracture pattern occurs very frequently that it could serve as an early warning sign for clinicians.

International studies have long catalogued rib fractures the the most common injury after blunt chest trauma: middle ribs (4th-9th) break more often in motor vehicle collisions due to lateral compression forces (Rhea et al., 1982; Al-Hassani et al., 2010). In parallel Nigerian contexts, surveys of chest radiographs have confirmed rib fractures in roughly one third of trauma radiographs, with additional pneumothorax in up to 15% of cases (Sowunmi et al. 2016).

More recently, Caragounis *et al.,* (2021) explained that younger RTA patients sustain lateral and posterior flail segments , while older patients will often present with falls and anterior or sternal involvements. What remains unexplored could be wether a specific rib level or even an unexpected site such as the sternoclavicular joint presents as a signature injury among RTA victims.

1.2 Statement of Problem

In high volume emergency departments around the world, routine chest X-ray reveal rib and clavicular fractures at expected rates, informing analgesia, respiratory supports and surgical interventions (Lewis et al., 2021; Rhea et al., 1982). Text book patterns like middle rib breaks, single or flail segments, constitute what we recognize as normal practice.

This study aims to fill in the gap by systematically reviewing chest radiographs of RTA victims in Benin city, tabulating the fracture locations by rib number, whether sternal involvement, clavicular breaks, and scapular findings. By doing so, we hope to determine whether a particular fracture pattern predominates in this population or there have been subtle patterns that have been evaded.

1.3 Research Question

1) What is the frequency of fractures at each rib level as well as sternal, clavicular and scapular breaks on chest radiograph of RTA patients in Benin city?

2) What is the type of fracture that is most occurring?

3) What are the associated radiographic findings such as pneumothorax, hemothorax, pulmonary contusion, and correlate them with fracture patterns?

1.4 General Objective of the Study

To evaluate common fractures detected on chest radiograph of road traffic accident patients in Benin city

1.5 Specific Objectives

1. To determine the frequency of fractures at each rib level as well as sternal, clavicular and scapular breaks on chest radiograph of RTA patients in Benin city.

2. To identify the type of fracture that is occurring.

3. To catalogue associated radiographic findings such as pneumothorax, hemothorax, pulmonary contusion, and correlate them with fracture patterns.

1.6 Significance of study

By distinguishing and pinpointing which chest wall fractures commonly follow RTAs, and by uncovering unexpected recurrent injuries, this study will give edge to clinicians' radiographic vigilance. Recognizing a recurring pattern could help streamline triaging, prompt targeted analgesia, guide imaging protocols, and improve outcomes for trauma victims in Benin City and comparable environments.

1.7 Research Hypothesis

Alternative Hypothesis: There is a significant correlation between fracture patterns and associated radiographic findings

Null Hypothesis: There is no significant correlation between fracture patterns and associated radiographic findings

1.8 Scope of Study

The study included review of adult patients radiographs presenting after RTAs whose first radiograph was a chest radiograph (which usually follows the trauma series request) in UBTH. The study focused solely on fractures and associated injuries not the overall outcome of the investigation.

1.9 Definition of terms

- Road Traffic Accident: Any vehicular Collision involving motorized transport that result in patient referral for emergency imaging.
- Flail Segment: Two or more adjacent ribs fractured in two or more places, leading to a free-floating chest wall portion detectable on a radiograph.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 General Anatomy

The chest wall comprises the skin, fat, muscles, and thoracic skeleton. It provides protection to vital organs (e.g., heart and major vessels, lungs, liver), supports respiratory mechanics (Standring, 2021) and provides stability for movement of the shoulder girdles and upper arms. Although the thoracic skeleton consists of rigid bones and cartilage, its interconnection with the muscular components forms for a dynamic structure that is able to expand during inspiration, thereby increasing intrathoracic volume and allowing for maximal breaths to take place. An in-depth understanding of chest wall anatomy is paramount to those performing any surgical procedure of the chest or breast.

2.1.2 Gross Anatomy

Identifying and marking the relevant surface anatomy of the chest wall can assist in preparation for surgery on the chest.

Surface anatomy

The front of the chest has several important surface landmarks used for orientation and clinical assessment. These include the nipple and the suprasternal (jugular) notch — a visible depression at the upper end of the sternum. The mid-sternal line (also called the anterior median line) runs vertically along the sternum from the suprasternal notch down to the xiphoid process and can extend inferiorly to the umbilicus. This central line is useful for maintaining symmetry in surgical planning, such as during median sternotomy or reconstructive procedures. On each side of the sternum lies the lateral sternal line, which helps identify the location of the internal thoracic artery, positioned about one centimetre lateral to the sternum. The mid-clavicular line runs downward through the midpoint of the clavicle and typically passes just medial to the nipple in men. This line is a crucial reference during procedures such as needle decompression for pneumothorax, which is performed in the second or third intercostal space. The xiphoid process, forming the inferior tip of the sternum, aligns approximately with the T9 – T10 vertebral levels and serves as a key landmark for cardiopulmonary resuscitation (CPR) and subxiphoid surgical approaches.

The lateral surface landmarks of the chest are based around the axilla (armpit). The axilla is bordered superiorly by the outer edge of the first rib, the mid-section of the clavicle, and the upper margin of the scapula. Inferiorly, it ends at the lower margin of the axillary fold. The pectoralis major muscle defines the anterior boundary, while the latissimus dorsi muscle forms the posterior boundary. The anterior axillary line runs along the anterior fold, serving as a guide for inserting chest drains or planning breast surgeries. Similarly, the posterior axillary line follows the posterior fold, and the mid-axillary line descends vertically through the centre of the axilla.

Skeletal Framework of the Thorax

The thoracic skeleton is composed of 12 pairs of ribs that articulate posteriorly with 12 thoracic vertebrae and anteriorly with the sternum via costal cartilages (except for the last two or three pairs). Together, these bones create a flexible yet protective cage for vital organs such as the heart and lungs, while also facilitating breathing movements.

Thoracic Vertebrae

Each thoracic vertebra features superior and inferior costal facets on its body for articulation with the heads of ribs, as well as transverse costal facets on the transverse processes for the tubercles of ribs. The first thoracic vertebra (T1) has a complete superior facet for the first rib and a partial inferior facet for the second rib. T10 has a single superior facet, while T11 and T12 each possess one pair of complete facets corresponding to their ribs. The spinous processes slope downward and overlap the vertebra below, increasing spinal stability. The costovertebral joints connect each rib head to adjacent vertebral bodies via ligaments, while the costotransverse joints—between rib tubercles and vertebral transverse processes—permit controlled rib movement during respiration. The upper ribs mainly move in the sagittal plane, while the lower ribs move more transversely. The intervertebral foramina, bordered by the pedicles and vertebral bodies, allow the spinal nerves and vessels to exit the thoracic spine.

Ribs

There are 12 pairs of ribs, categorized according to their anterior connections.

- True ribs (1 – 7): Attach directly to the sternum through their own costal cartilages.
- False ribs (8 – 10): Connect indirectly via a shared costal arch.
- Floating ribs (11 – 12): Have no anterior attachment and terminate within the posterior abdominal wall.

Each rib comprises four anatomical parts:

1. Head – articulates with the vertebral bodies.

2. Neck – the narrow segment between the head and tubercle.

3. Tubercle – articulates with the transverse process of its corresponding vertebra.

4. Shaft – the curved body ending at the costochondral junction, where it meets hyaline cartilage.

Neurovascular bundles run along the inferior margin of each rib within the costal groove. Therefore, surgical or procedural access to the intercostal spaces (such as chest tube insertion) should always occur just above the upper border of the rib below to avoid injury to these structures. The intercostal spaces are wider anteriorly than posteriorly and are more spacious between the upper ribs than the lower ones.

The Sternum

The sternum is a flat, elongated bone located in the anterior midline of the thoracic cage. It is made up of three parts: the manubrium, body, and xiphoid process. These segments develop separately during embryogenesis and are united by cartilaginous joints that provide flexibility and strength to the chest wall (Standring, 2021; Vatzia et al., 2021).

Embryologically, the sternum forms from paired mesenchymal bars that fuse along the midline in a top-to-bottom sequence (Sharma et al., 2023). The manubrium develops first, followed by the body and then the xiphoid process. Ossification occurs gradually from late fetal life through early adulthood, with fusion typically completed by the second or third decade (Bayaroğulları et al., 2014).

The manubrium, the uppermost part, is quadrangular and lies opposite the T3 – T4 vertebral levels (Rizvi & Sawant, 2024). It articulates with the clavicles and the first pair of ribs, and joins the sternal body at the manubriosternal joint (the sternal angle or Angle of Louis), which corresponds to the T4 – T5 level.

The body of the sternum extends from T5 to T9 and develops from four sternebrae that fuse during growth (Standring, 2021). Its sides contain facets for the attachment of the costal cartilages of ribs two through seven.

The xiphoid process forms the lower portion of the sternum, located near the T10 vertebral level (Lee et al., 2004). It may appear pointed, rounded, or bifid in shape and becomes ossified with age.

Functionally, the sternum provides attachment sites for muscles such as the pectoralis major, sternocleidomastoid, sternohyoid, and sternothyroid. It also anchors the superior sternopericardial ligament and serves as an important surface landmark in clinical examination and imaging, helping to locate the second costal cartilage and guide procedures such as auscultation and CPR.

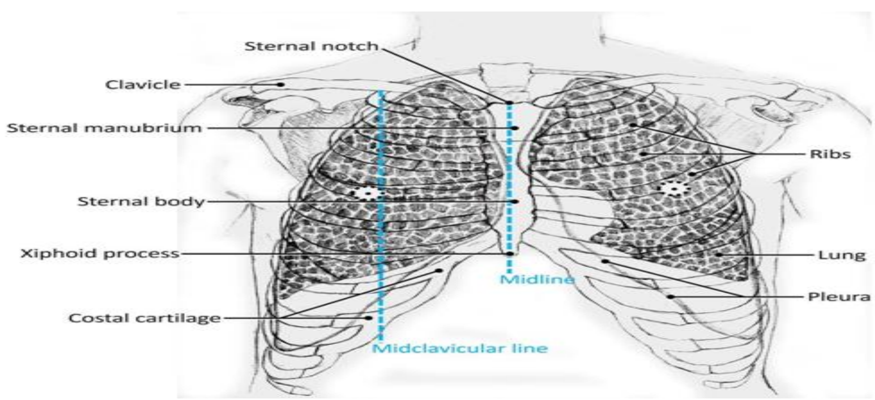

Fig 2.1 Image of the chest. (Source: *Wikipedia*)

2.1.3 Radographic Examination Of The Chest.

Chest radiography remains one of the most frequently performed diagnostic imaging procedures in clinical practice. Despite its routine use, it provides critical information regarding the lungs, heart, pleura, diaphragm, bones, and surrounding soft tissues, making it indispensable in both acute and follow-up care.

Exposure Factors

Selecting the correct exposure parameters is fundamental to obtaining diagnostic images. Improper exposure settings may obscure existing pathology or introduce artefacts that mimic disease. This is particularly important in portable chest radiography, where consistency in exposure ensures reliable comparison between serial images taken during patient management.

To promote uniformity, many healthcare facilities have established standardized exposure protocols for portable chest X-rays. Modern imaging technologies — such as computed radiography (CR) and digital radiography (DR) — have largely replaced the older film-screen systems because of their wide dynamic range, allowing minor variations in technique without significant image degradation. Nevertheless, radiographers must remain vigilant about achieving optimal exposure indicator values and minimizing repeat examinations.

Radiographers are required to adjust technical factors based on the patient’s condition and the radiographic findings. For example, conditions that increase chest density (additive pathologies), such as pneumonia or pleural effusion, demand a higher kilovoltage peak (kVp) or milliampere-seconds (mAs) to achieve adequate penetration. Conversely, diseases that increase air content within the thorax (destructive pathologies), such as emphysema, require lower exposure values. Understanding how disease processes influence radiographic density enables the radiographer to tailor exposure settings appropriately.

The use of automatic exposure control (AEC) has further improved image quality and consistency. However, it must be applied with care. Activation of AEC detectors over regions of abnormal density — for instance, aerated or consolidated lung fields — may result in underexposure or overexposure. Therefore, radiographers must critically assess the patient's clinical state and anatomical variations before choosing detector positions. Even when the image appears acceptable, it is essential to verify the exposure index to ensure adherence to departmental standards.

Chest Radiograph Projections

The standard posteroanterior (PA) chest projection, taken in the erect position, is the preferred view for evaluating the thorax. On a well-positioned PA radiograph, the costophrenic and cardiophrenic angles should be clearly visible, and the right hemidiaphragm normally lies about 1–2 cm higher than the left due to the presence of the liver beneath it. When patients are imaged in the supine position, as often required in trauma or critically ill cases, abdominal pressure may elevate the diaphragm and obscure the lower lung fields.

When an erect position is not feasible, an anteroposterior (AP) projection is obtained, typically using a mobile X-ray unit. Wherever possible, the patient should be positioned semi-erect to allow visualization of air-fluid levels and prevent distortion. The X-ray beam should remain perpendicular to the image receptor to reduce magnification of the mediastinal structures — especially the heart, which lies farther from the detector in the AP projection. Using a 72-inch (180 cm) source-to-image distance (SID) also helps minimize geometric magnification. In digital systems, short-dimension grids are frequently employed to enhance contrast and reduce scatter.

Additional views may be obtained to clarify specific findings:

- Lateral projection: evaluates retrosternal and posterior lung fields.

- Decubitus views: detect pleural fluid or free intrathoracic air by showing fluid layering or air movement. For example, a right lateral decubitus image—taken with the patient lying on the right side—helps demonstrate small pleural effusions or pneumothorax.

- Oblique and lordotic projections: separate overlapping structures such as ribs or clavicles and are used to visualize apical lung lesions that may be obscured on standard views.

Image Quality and Evaluation

Assessment of a chest radiograph's adequacy involves evaluating positioning, inspiration, penetration, and rotation:

- Inspiration: A well-inspired PA film should show at least ten posterior ribs within the lung field.

- Penetration: The vertebral bodies and intervertebral spaces should be faintly visible through the cardiac shadow.

- Rotation: The medial ends of the clavicles should be equidistant from the vertebral spinous processes.

The typical range of diaphragmatic motion between full inspiration and expiration is around 3 cm. Observing this movement on serial radiographs helps evaluate diaphragmatic function and lung expansion.

Special Considerations

Oblique chest views can be used to visualize the sternum, esophagus, or thoracic spine when these structures are superimposed on standard projections. The lordotic view, obtained with the patient leaning backward, provides an unobstructed image of the lung apices—an area prone to disease processes such as tuberculosis or apical fibrosis.

By adhering to appropriate positioning, exposure selection, and evaluation criteria, radiographers ensure high-quality diagnostic chest radiographs that support accurate interpretation and patient care.

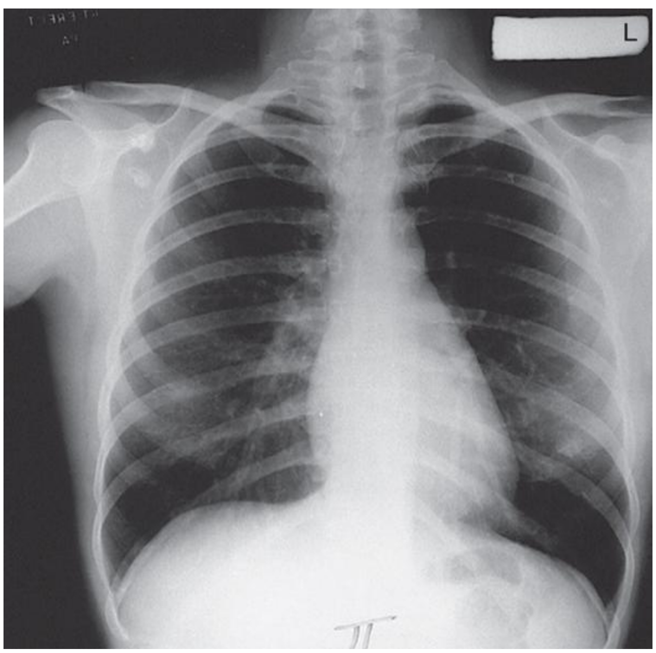

Fig 2.2 A normal chest radiograph(source: *Clark's positioning and techniques*).

2.1.4 Chest Trauma

A chest injury, also known as chest trauma, is any form of physical injury to the chest including the ribs, heart and lungs. Chest injuries account for 25% of all deaths from traumatic injury

(Andrew et al., 2002). Typically chest injuries are caused by blunt mechanisms such as direct, indirect, compression, contusion, deceleration, or blasts (Marini et al., 2001) caused by motor vehicle collisions or penetrating mechanisms such as stabbings (Feliciano et al., 2012).

Chest injuries can be classified as blunt or penetrating. Blunt and penetrating injuries have different pathophysiologies and clinical courses.

Specific types of injuries include but are not limited to those highlighted, but for the purpose of our study:

- Injuries to the chest wall
- Chest wall contusions or hematomas
- Rib fractures
- Flail chest
- Sternal fractures
- Fractures of the shoulder girdle

The rib fractures , flail chest and sternal fractures are discussed in details.

Rib Fractures

A rib fracture is simply a broken rib bone, an injury that typically causes chest pain which gets worse when the person breathes in. Bruising may also appear at the spot where the break occurred. When several adjacent ribs are broken in multiple places, the result is a serious condition called flail chest. Potential complications from a simple fracture include a collapsed lung (pneumothorax), bruising of the lung tissue (pulmonary contusion), and pneumonia.

Rib fractures are most often caused by a direct, forceful impact to the chest, such as what happens in a car crash or from a crush injury. Less commonly, they can be caused by a severe cough or by the presence of metastatic cancer that weakens the bone. The ribs in the middle of the rib cage are the ones most frequently fractured. Breaks involving the first or second ribs are generally considered more dangerous due to their association with an increased risk of complications. Diagnosis is initially based on the patient's reported symptoms and is often confirmed with medical imaging.

Pain control is a primary focus of treatment. This may involve medications like paracetamol (acetaminophen), NSAIDs, or opioids. A nerve block can also be used as an option to manage severe pain. While fractured ribs may occasionally be wrapped, this practice carries a risk of increasing complications. For patients diagnosed with a flail chest, surgical intervention has been shown to improve outcomes. Rib fractures are a common injury following any significant trauma.

Rib fractures don't always require direct trauma; they can happen during recreational activities or even from cardiopulmonary resuscitation (CPR), which is known to cause fractures of the ribs and sternum. Certain diseases, such as cancer or rheumatoid arthritis, can weaken the bone and lead to fractures. An extremely powerful or prolonged cough, such as with whooping cough, can also break a rib. While a simple fall can cause a rib fracture in older individuals, automobile accidents remain one of the most common causes of this injury in adults.

In terms of diagnosis via imaging, standard plain X-rays are often effective at detecting breaks where the bone pieces have separated (displaced fractures) but frequently miss ones where the rib remains in place (undisplaced fractures). CT scanning, however, is generally capable of identifying both types of rib breaks.

Fig 2.3 Chest radiograph showing fracture on the right rib cage. (source: *Wikipedia*)

Flail Chest

Flail chest is a life-threatening medical condition that occurs when a segment of the rib cage breaks due to trauma and becomes detached from the rest of the chest wall. Two of the symptoms of flail chest are chest pain and shortness of breath(Athanassadi et al., 2004). It occurs when multiple adjacent ribs are broken in multiple places, separating a segment, so a part of the chest wall moves independently. The number of ribs that must be broken varies by differing definitions: some sources say at least two adjacent ribs are broken in at least two places,(Lorene & Laura, 2005) some require three or more ribs in two or more places (Keel & Meier, 2007). The flail segment moves in the opposite direction to the rest of the chest wall: because of the ambient pressure in comparison to the pressure inside the lungs, it goes in while the rest of the chest is moving out, and vice versa. This so-called "paradoxical breathing"is painful and increases the work involved in breathing.

Flail chest is usually accompanied by a pulmonary contusion, a bruise of the lung tissue that can interfere with blood oxygenation(Yamamoto et al., 2005). Often, it is the contusion, not the flail segment, that is the main cause of respiratory problems in people with both injuries(Hemmila & Wahl, 2005). Surgery to fix the fractures appears to result in better outcomes (Coughlin et al., 2016).

Two of the symptoms of flail chest are chest pain and shortness of breath (Athanassadi et al, 2004).

The characteristic paradoxical motion of the flail segment occurs due to pressure changes associated with respiration that the rib cage normally resists:

During normal inspiration, the diaphragm contracts and intercostal muscles pull the rib cage out. Pressure in the thorax decreases below atmospheric pressure, and air rushes in through the trachea. The flail segment will be pulled in with the decrease in pressure while the rest of the rib cage expands.

During normal expiration, the diaphragm and intercostal muscles relax increasing internal pressure, allowing the abdominal organs to push air upwards and out of the thorax. However, a flail segment will also be pushed out while the rest of the rib cage contracts.

Paradoxical motion is a late sign of flail segment; therefore, an absence of paradoxical motion does not mean the patient does not have a flail segment.

The constant motion of the ribs in the flail segment at the site of the fracture is extremely painful, and, untreated, the sharp broken edges of the ribs are likely to eventually puncture the pleural sac and lung, possibly causing a pneumothorax. The concern about "mediastinal flutter" (the shift of the mediastinum with paradoxical diaphragm movement) does not appear to be merited(Molnar, 2007). Pulmonary contusions are commonly associated with flail chest and that can lead to respiratory failure. This is due to the paradoxical motions of the chest wall from the fragments interrupting normal breathing and chest movement. Typical paradoxical motion is associated with stiff lungs, which requires extra work for normal breathing, and increased lung resistance, which makes air flow difficult(Bemelman et al., 2010).

The respiratory failure from the flail chest requires mechanical ventilation and a longer stay in an intensive care unit(Marasco et al., 2013). It is the damage to the lungs from the flail segment that is life-threatening.

The most common causes of flail chest injuries are vehicle collisions, which account for 76% of flail chest injuries (Borman et al., 2006). Another main cause of flail chest injuries is falling. This mainly occurs in the elderly, who are more impacted by the falls as a result of their weak and frail bones, unlike their younger counterparts who can fall without being impacted as severely. Falls account for 14% of flail chest injuries(Athanassadi et al, 2004).

Flail chest typically occurs when three or more adjacent ribs are fractured in two or more places, allowing that segment of the thoracic wall to displace and move independently of the rest of the chest wall. Flail chest can also occur when ribs are fractured proximally in conjunction with disarticulation of costal cartilages distally. For the condition to occur, generally there must be a significant force applied over a large surface of the thorax to create the multiple anterior and posterior rib fractures. Rollover and crushing injuries most commonly break ribs at only one point, whereas for flail chest to occur a significant impact is required, breaking the ribs in two or more places (Bjerke & Scott, 2007). This can be caused by forceful accidents such as the aforementioned vehicle collisions or significant falls. In the elderly, it can be caused by deterioration of bone, although rare. In children, the majority of flail chest injuries result from common blunt force traumas or metabolic bone diseases, including a group of genetic disorders known as osteogenesis imperfecta (Gipson & Tobias, 2006).

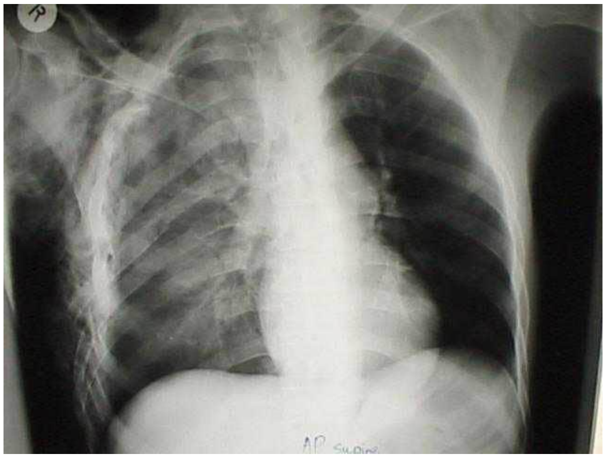

fig 2.4 Radiograph of a flail chest with associated contusion. (Source: *Radiopedia*).

Sternal Fracture

A sternal fracture is a fracture of the sternum (the breastbone), located in the center of the chest. The injury, which occurs in 5–8% of people who experience significant blunt chest trauma, may occur in vehicle accidents, when the still-moving chest strikes a steering wheel or dashboard (Beck et al., 2005) or is injured by a seatbelt. Cardiopulmonary resuscitation (CPR), has also been known to cause thoracic injury, including sternum and rib fractures. Sternal fractures may also occur as a pathological fracture, in people who have weakened bone in their sternum, due to another disease process (Smith & Ball, 1998).

Sternal fracture can interfere with breathing by making it more painful; however, its primary significance is that it can indicate the presence of serious associated internal injuries, especially to the heart and lungs (Marini & Wheeler, 2006). Signs and symptoms include crepitus (a crunching sound made when broken bone ends rub together) (Beck et al., 2005),pain, tenderness, bruising, and swelling over the fracture site (Livingstone & Hauser, 2004). The fracture may visibly move when the person breathes, and it may be bent or deformed,(Livingstone & Hauser,

2004) potentially forming a "step" at the junction of the broken bone ends that is detectable by palpation (Marini & Wheeler, 2006).Associated injuries such as those to the heart may cause symptoms such as abnormalities seen on electrocardiograms (Beck et al, 2005).

The upper and middle parts of the sternum are those most likely to fracture (Owens et al., 2005), but most sternal fractures occur below the sternal angle (Beck et al. 2005).

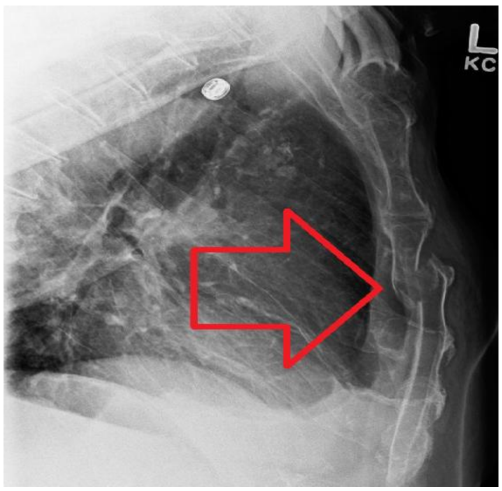

fig 2.5 Radiograph showing a displaced sternal fracture. (Source : *Wikipedia*).

2.2 Empirical Review

Chest radiography continues to serve as a critical first-line imaging tool in the assessment of thoracic trauma, particularly in acute and emergency settings. Ho and Gutierrez (2009) provided a comprehensive review of its role in evaluating thoracic polytrauma, emphasizing the importance of chest X-rays in rapidly assessing injuries to the chest wall, diaphragm, lungs, and mediastinum. While computed tomography (CT) remains the gold standard in terms of sensitivity, they argued that in high-pressure situations where patients are unstable, portable chest radiography is often the only feasible option. Their work underscored that even with limitations such as poor patient positioning or suboptimal view angles, the chest X-ray can reveal a broad range of trauma-related abnormalities, from rib fractures and pneumothorax to diaphragmatic ruptures and foreign bodies lodged in soft tissue.

Rhea et al. (1982) took a focused look at the use of rib series films compared to standard chest radiography in detecting rib fractures. Their prospective study of 100 patients revealed that while 29% had radiographically confirmed rib fractures, most of the complications that influenced treatment such as hemothorax and pneumothorax were identified only on standard posteroanterior chest films, not on rib-specific views. The study concluded that rib films were redundant in most cases and did not significantly impact treatment outcomes, advocating instead for the use of standard chest radiographs due to their greater diagnostic and economic efficiency.

Lewis et al. (2021) added depth by analyzing pulmonary trauma with a particular focus on imaging manifestations. They noted that chest radiographs are often the initial diagnostic modality for injuries such as contusions, lacerations, and pneumothorax, although CT remains more sensitive. The study emphasized that pulmonary contusions may be missed in the first six hours post-trauma, peaking in visibility after 48–72 hours. Moreover, they highlighted that while CT improves detection, chest radiography still plays a pivotal role in the rapid triage and early management of thoracic trauma patients in both high- and low-resource environments.

Sowunmi et al. (2016), in a Nigerian context, conducted a retrospective review of 200 patients and confirmed that road traffic accidents were the leading cause of chest trauma. Rib fractures were the most common radiographic finding, followed by lung collapse and hemothorax. Their study emphasized the importance of chest radiographs in resource-limited settings, where access to advanced imaging is not always feasible. They emphasized that despite the limitations of plain X-rays, they remain a vital diagnostic tool for identifying trauma-related complications and guiding immediate care decisions.

Caragounis et al. (2021) shifted the focus toward the surgical management of chest wall trauma. Their retrospective study of 211 patients revealed how mechanisms of injury vary by age, with younger patients commonly involved in traffic accidents and older patients more frequently sustaining falls. Lateral and posterior flail segments were most common, but sternal and anterior flail injuries were more often associated with bilateral trauma and frontal collisions. Importantly, patients involved in traffic accidents often sustained injuries across three or more body regions, and 18% of those who underwent thoracotomy were found to have diaphragmatic injuries. Their findings stress that the mechanism of injury not only influences the fracture pattern but also correlates strongly with associated intra-thoracic and extra-thoracic injuries.

Finally, the study by Al-Hassani et al. delved into the predictive relationship between rib fracture zones and associated thoracic or abdominal organ injuries. Analyzing patterns among 310 patients, the authors demonstrated that lower rib fractures (ribs 9–12) were significantly associated with solid organ injuries—particularly to the spleen, liver, and kidneys—while upper rib fractures were more likely to be accompanied by sternal and scapular fractures. The number of rib fractures was positively correlated with the incidence of pulmonary contusions and chest wall injuries, though not necessarily with abdominal injuries. Their findings support the use of rib fracture location as a clinical predictor for underlying organ trauma and reinforce the need for comprehensive imaging and multidisciplinary assessment in trauma management.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Setting

This study was conducted at the University of Benin Teaching Hospital (UBTH), a major tertiary healthcare facility located in Benin City, Edo State, Nigeria. UBTH serves as a referral centre for trauma cases across the state and neighboring regions. The hospital is equipped with a dedicated accident and emergency unit and radiology department that provide standard imaging, including chest radiographs, for patients involved in road traffic accidents (RTAs). The high influx of patients and trauma series carried out in UBTH makes it an ideal setting for this research as it will provide a robust sample size.

3.2 Research Design

A retrospective cross-sectional descriptive design was adopted. This design allows for the analysis of existing chest radiographs and corresponding clinical records of RTA patients over a specified period without influencing the course of patient management or outcomes.

3.3 Target Population

The target population consisted of all adult patients (aged 18 years and above) who sustained road traffic accidents and underwent chest radiography as part of their initial trauma assessment at UBTH over a 2-year period (January 2022 to December 2024).

Inclusion criteria:

- Patients who are 18 years and above.
- Chest radiographs taken during trauma series for RTA patients.
- Radiographs of adequate diagnostic quality and complete records.

Exclusion criteria:

- Non-RTA cases.

- Incomplete or poor-quality radiographs.

- Duplicate imaging for the same trauma incident

3.4 Sample Technique and Sample Size

This study was carried out using a purposive sampling technique.

Sample size was gotten using Taro Yamane formula.

$n = N/1+N(e^2)$

$n = 344/1+344(0.05*0.05)$

$n = 344/1+344(0.0025)$

$n = 344/1.86$

$n = 185$

3.5 Instrument of Data Collection

Data was collected using a structured checklist. The checklist covered relevant information such as;

- Demographic information (age, sex).

- Fracture location (rib level 1–12, sternum, clavicle, scapula).

- Associated findings (pneumothorax, hemothorax, pulmonary contusion).

- Date of imaging.

3.6 Validity of Instrument

The checklist underwent face and content validation by experts in radiology and trauma surgery to ensure it adequately captures all variables relevant to the study objectives. These experts included radiographers, radiologists and accident and emergency physicians. A pilot review of 10 radiographs was conducted to test the clarity and completeness of the checklist, with adjustments made as necessary.

3.7 Reliability of Instrument

To ensure reliability, two independent reviewers assessed 20 randomly selected radiographs. The agreement between reviewers was measured using Cohen's kappa statistic, aiming for a value of ≥0.75, which indicates substantial agreement.

3.8 Method of Data Collection

Following ethical approval, UBTH's radiograph archive was accessed alongside corresponding patient records. Data was extracted manually onto the checklist. Patient anonymity was preserved by removing any identifying information.

3.9 Method of Data Analysis

Data was entered into SPSS version 25 for analysis. Descriptive statistics (frequencies, percentages, means) was used to summarize the data. Inferential statistics, including chi-square tests, was applied to identify any statistically significant patterns. A p-value <0.05 was considered significant. Results were presented in tables, charts, and graphs.

3.10 Ethical Considerations

Approval was sought from the UBTH Research and Ethics Committee. Patient confidentiality was strictly maintained. Data collected was strictly used for research purposes. Due to the sensitivity of patient's information, their names were removed before data was collected. The data was stored in password protected computer and accessed only by authorized personnel.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

Objective 1

To determine the frequency of fractures at each rib level as well as sternal, clavicular and scapular breaks on chest radiographs of RTA patients in Benin City.

Table 4.1: Rib Fractures by Anatomical Region (n = 185)

Region	Frequency (n)	Percentage (%)
Upper ribs (1–3)	55	29.7
Middle ribs (4–8)	136	73.5
Lower ribs (9–12)	54	29.2

From table 4.1 the middle ribs (4–8) accounted for nearly three-quarters of all rib fractures, confirming their anatomical vulnerability in blunt thoracic trauma. Upper-rib fractures, though less common, are clinically significant as they often indicate high-energy impact. Lower-rib fractures were also present in about 29% of cases, suggesting mechanisms that involve oblique or posterolateral force, which can raise suspicion of associated abdominal injuries.

Table 4.2: Distribution of Sternal, Clavicular and Scapular Fractures (n = 185)

Region	Frequency (n)	Percentage (%)
Sternum – Manubrium	7	3.8
Sternum – Body	10	5.4
Sternum – Xiphoid	3	1.6
Any sternal fracture	20	10.8
Clavicle – Right	14	7.6
Clavicle – Left	11	5.9
Any clavicular fracture	25	13.5
Scapula – Right	7	3.8
Scapula – Left	5	2.7
Any scapular fracture	12	6.5

According to table 4.2 sternal fractures were observed in about 11% of cases, with the body of the sternum most often affected—likely due to anterior impact from seat belts or steering wheels. Clavicular fractures (13.5%) suggest shoulder restraint and lateral trauma mechanisms, while scapular fractures (6.5%), though relatively rare, signal high-energy injuries that often co-exist with severe thoracic trauma.

Objective 2

To identify the type of fracture that is occurring.

Table 4.3: Multiple-Response Distribution of Fracture Types (n = 185 patients)

Fracture Type	Frequency (n)	% of All Selections
Non-displaced	112	42.3
Displaced	89	33.6
Comminuted	36	13.6
Segmental	28	10.6
Total selections	265	100.0

From table 4.3 the results show that non-displaced fractures were the most frequently recorded, contributing 42.3% of all fracture types. Displaced fractures followed closely at 33.6%, while comminuted and segmental patterns accounted for 13.6% and 10.6% respectively. This indicates that although simple fractures were more common, a considerable proportion of the chest radiographs revealed complex fracture configurations.

Objective 3

To catalogue associated radiographic findings such as pneumothorax, hemothorax, pulmonary contusion, and correlate them with fracture patterns.

Table 4.4: Associated Radiographic Findings among RTA Patients (n = 185)

Finding	Frequency (n)	Percentage (%)
Pneumothorax	42	22.7
Hemothorax	35	18.9
Pulmonary Contusion	28	15.1
Any associated finding	83	44.9

According to table 4.4 pneumothorax was the most common associated finding, present in 22.7% of cases, followed by hemothorax (18.9%) and pulmonary contusion (15.1%). Overall, nearly half of the patients (44.9%) had at least one associated radiographic complication.

Table 4.5: Fracture Patterns by Presence of Pneumothorax (n = 185)

Fracture Pattern	Pneumothorax Absent (n)	Pneumothorax Present (n)	Pneumothorax Present (%)
None	40	2	4.8
Isolated rib fracture	52	10	16.1
Rib + other site	28	15	34.9
≥3 distinct sites	23	15	39.5
Total	143	42	22.7

Table 4.5 showed that the likelihood of pneumothorax increased with the complexity of fracture patterns, rising from 4.8% among patients with no fractures to nearly 40% in those with three or more fracture sites.

Table 4.6: Fracture Patterns by Presence of Hemothorax (n = 185)

Fracture Pattern	Hemothorax Absent (n)	Hemothorax Present (n)	Hemothorax Present (%)
None	41	1	2.4
Isolated rib fracture	55	7	11.3
Rib + other site	30	13	30.2
≥3 distinct sites	24	14	36.8
Total	150	35	18.9

According to table 4.5 hemothorax was rarely observed in patients without fractures but increased sharply in those with multiple fracture sites, reaching 36.8% in patients with three or more fractured regions.

Table 4.7: Fracture Patterns by Presence of Pulmonary Contusion (n = 185)

Fracture Pattern	Contusion Absent (n)	Contusion Present (n)	Contusion Present (%)
None	41	1	2.4
Isolated rib fracture	56	6	9.7
Rib + other site	32	11	25.6
≥3 distinct sites	28	10	26.3
Total	157	28	15.1

According to table 4.7 pulmonary contusion was almost absent among patients with no or single rib fractures, but its occurrence rose significantly with more complex fracture patterns, affecting over one-quarter of patients with multiple fracture sites.

4.2 Hypothesis Testing

H_1: There is a significant correlation between fracture patterns and associated radiographic findings.

H_0: There is no significant correlation between fracture patterns and associated radiographic findings.

Table 4.8: Chi-Square Test of Association between Fracture Pattern and Pneumothorax

Test Statistic	Value	df	p-value	Interpretation
χ^2	21.46	3	<0.001	Significant

Pneumothorax occurrence was strongly associated with fracture pattern ($p < 0.001$). The null hypothesis is rejected for pneumothorax.

Table 4.9: Chi-Square Test of Association between Fracture Pattern and Hemothorax

Test Statistic	Value	df	p-value	Interpretation
χ^2	19.82	3	<0.001	Significant

Hemothorax showed a significant association with fracture pattern ($p < 0.001$). The null hypothesis is rejected for hemothorax.

Table 4.10: Chi-Square Test of Association between Fracture Pattern and Pulmonary Contusion

Test Statistic	Value	df	p-value	Interpretation
χ^2	14.27	3	0.003	Significant

Pulmonary contusion was significantly associated with fracture pattern ($p = 0.003$). The null hypothesis is rejected for pulmonary contusion.

Across pneumothorax, hemothorax, and pulmonary contusion, the associations with fracture pattern were statistically significant ($p < 0.05$). Therefore, H_0 is rejected and H_1 is accepted.

Chi-square analysis showed statistically significant associations between fracture patterns and all three major complications:

Pneumothorax: $\chi^2 = 21.46$, df = 3, $p < 0.001$

Hemothorax: $\chi^2 = 19.82$, df = 3, $p < 0.001$

Pulmonary contusion: $\chi^2 = 14.27$, df = 3, $p = 0.003$

Since p-values were all less than 0.05, the null hypothesis was rejected across the board.

These results confirm what the raw data already hinted at: the more complex the fracture pattern, the higher the likelihood of complications. Pneumothorax, hemothorax, and pulmonary contusion all clustered significantly in patients with multiple or unstable fractures. This means that fracture distribution on a chest radiograph is not just descriptive but strongly predictive of the injuries lurking underneath.

4.3 Discussion of Findings

Objective 1

To determine the frequency of fractures at each rib level as well as sternal, clavicular and scapular breaks on chest radiographs of RTA patients in Benin City.

From the assessment of 185 chest radiographs, rib fractures were most frequently observed in the middle ribs (4th–8th), accounting for 136 cases (73.5%). The upper ribs (1st–3rd) were affected in 55 cases (29.7%), while lower ribs (9th–12th) appeared in 54 cases (29.2%). In addition to rib injuries, 20 patients (10.8%) presented with sternal fractures, mostly at the sternal body, while clavicular fractures were recorded in 25 patients (13.5%) and scapular fractures in 12 patients (6.5%). Because several patients sustained injuries in more than one region, the overall percentages exceed 100%.

The pattern of injury distribution highlights the vulnerability of the middle ribs during road traffic accidents (RTAs). Anatomically, these ribs form the broadest curvature of the rib cage and are directly exposed to lateral compression and side-impact forces. Consequently, fractures involving ribs 5–7 are commonly encountered in blunt chest trauma and correlate well with clinical experience. Although less frequent, upper-rib (1st–3rd) fractures are clinically significant, as these ribs are naturally protected beneath the shoulder girdle. Their involvement often indicates a high-impact mechanism of injury. The detection of upper-rib fractures on plain chest radiographs should therefore prompt a careful evaluation for associated conditions such as pneumothorax or vascular injury.

In contrast, lower-rib (9th–12th) fractures generally suggest oblique or posterolateral impacts, while fractures involving the sternal body are typically consistent with anterior deceleration injuries, such as those caused by seat belt or steering wheel impact. Clavicular fractures often result from shoulder-belt loading or lateral shoulder trauma and, when seen alongside upper-rib fractures, are indicative of a higher-energy mechanism. Scapular fractures, though relatively rare, signify significant force transmission and should raise the suspicion of multi-system trauma.

Previous studies have similarly reported rib fractures as the most frequent thoracic injuries in RTA patients within Nigeria (Sowunmi et al., 2016). The observed distribution pattern aligns with findings in Benin City, reinforcing the clinical reliability of chest radiography as the first-line imaging modality in suspected thoracic trauma cases, particularly for unstable patients. Despite its limitations, chest X-ray remains an effective tool for detecting key abnormalities such as rib fractures, pneumothorax, and hemothorax (Ho & Gutierrez, 2009).

Al-Hassani et al. established a relationship between upper-rib injuries and other chest wall fractures (such as sternal or scapular involvement), while lower-rib fractures were linked with possible intra-abdominal organ injury. These findings align closely with the present study, where middle-rib fractures predominated, and upper- or scapular fractures signified high-energy trauma. In practical terms, this distribution serves as a useful diagnostic guide within the Benin City clinical setting. The predominance of middle-rib involvement suggests that radiographers should carefully trace each rib during image review and maintain a low threshold for supplementary imaging, such as ultrasound or additional views, when abnormalities are suspected. The presence of upper-rib or sternal fractures should raise immediate concern for pneumothorax or subtle mediastinal injury, while scapular fractures necessitate a high suspicion for severe trauma. When lower ribs are involved, clinicians should also consider the possibility of solid organ injury. Ultimately, the observed fracture distribution provides not only descriptive data but also valuable predictive insight for appropriate triage and early management decisions.

Objective 2

To identify the type of fracture that is occurring.

A total of 265 distinct fracture occurrences were recorded from the 185 radiographs, as some patients sustained multiple fracture types. Non-displaced fractures were the most frequent, with 112 cases (42.3%), followed by displaced fractures in 89 cases (33.6%). Comminuted fractures were noted in 36 cases (13.6%), and segmental fractures in 28 cases (10.6%).

The predominance of non-displaced fractures indicates that most injuries involved lower-energy impacts, resulting in minimal structural disruption of the chest wall. These fractures, although painful, generally preserve thoracic stability and can often be managed easily. The significant proportion of displaced fractures, however, demonstrates that a considerable number of patients experienced high-impact trauma. Displacement suggests separation of bone fragments, which increases the risk of complications such as vascular injury, persistent pain, or respiratory compromise.

Comminuted and segmental fractures, though less frequent, represent the most severe patterns. A comminuted fracture involves multiple fragments, reflecting direct high-energy impact, while segmental fractures, with two breaks along the same rib, are indicative of potential flail chest, a condition characterized by irregular chest wall movement during respiration. Even though the incidence of these complex fractures was relatively low, their presence identifies patients requiring close observation and possibly surgical intervention.

These observations correspond with findings from previous research. Caragounis et al., 2021 reported that flail chest commonly occurred in lateral and posterior segments following high-energy traffic collisions, which aligns with the present findings. Similarly, Lewis et al., 2021 emphasized the ongoing value of chest radiographs in detecting unstable fracture patterns such as displaced or segmental breaks, despite the superior sensitivity of CT.

The pattern observed in this study shows the diverse severity of chest trauma sustained by RTA patients. For clinical practice in Benin City, this suggests that while non-displaced fractures may be managed conservatively, displaced, comminuted, or segmental patterns should immediately alert clinicians to potential instability and heightened risk. Such findings warrant careful monitoring, consideration for chest tube insertion, and possible surgery.

Objective 3

To catalogue associated radiographic findings such as pneumothorax, hemothorax, pulmonary contusion, and correlate them with fracture patterns.

Among the 185 radiographs evaluated, pneumothorax was detected in 42 patients (22.7%), hemothorax in 35 patients (18.9%), and pulmonary contusion in 28 patients (15.1%). Overall, 83 patients (44.9%) demonstrated at least one of these associated findings. The likelihood of complications increased significantly with the complexity of fractures; patients with three or more fracture sites showed the highest rates of pneumothorax (39.5%), hemothorax (36.8%), and pulmonary contusion (26.3%).

These results demonstrate that intrathoracic complications are relatively common in chest trauma following RTAs. Pneumothorax was the most frequently encountered, usually resulting from sharp rib fragments puncturing the pleura and causing air leakage into the thoracic cavity. Hemothorax, the next most frequent finding, reflects bleeding into the pleural space due to vascular injury. Pulmonary contusion, though slightly less common, represents a serious injury characterized by bruising of lung parenchyma, which may progress over time and impair gas exchange.

The correlation between fracture complexity and associated findings underscores the predictive role of radiographic evaluation. Simple or isolated rib fractures carried a lower risk of complications, whereas multiple or segmental fractures were almost always accompanied by additional abnormalities.

These findings are consistent with previous research. Rhea et al., 1982 demonstrated that major complications such as pneumothorax and hemothorax could be effectively detected on standard chest radiographs, a finding supported by Lewis et al., 2021, who emphasized the continuing relevance of plain films in trauma triage. Locally, Sowunmi et al., 2016 identified hemothorax and lung collapse as leading complications in Nigerian RTA patients, further supporting the present findings. Similarly, Al-Hassani et al. highlighted that both the number and anatomical zone of rib fractures are key predictors of associated thoracic and abdominal injuries.

For clinicians in Benin City, these results have direct practical relevance. The identification of multiple or complex rib fractures on a chest radiograph should immediately prompt vigilance for pneumothorax, hemothorax, or pulmonary contusion, even when these are not initially apparent. In settings where CT is not readily available, the chest X-ray remains a vital diagnostic and prognostic tool. It not only identifies fractures but also helps clinicians anticipate complications, prioritize monitoring, and determine when escalation of care, such as tube thoracostomy or surgical evaluation, is necessary. Thus, conventional radiography retains its crucial role in both the diagnosis and early management of chest trauma in resource-limited environments.

The statistical outcome of this study strongly correlates with the previous studies. Caragounis et al., 2021 showed that injury mechanism and chest wall fracture complexity correlated strongly with associated intra-thoracic injuries. Also, Al-Hassani et al. highlighted how rib fracture zones predict pulmonary contusions and abdominal organ injury. Findings from this study indicate that chest radiographs can reveal patterns that map directly onto patient risk in Benin City. The rejection of the null hypothesis means that radiographers and clinicians should treat fracture pattern as a red flag for complications. A patient with three or more fracture sites should not be managed the same way as one with a single non-displaced rib break. In practice, this evidence supports using plain chest radiography not only to confirm fractures but also to guide monitoring intensity, anticipate complications, and determine when to escalate care.

CHAPTER FIVE

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER STUDIES

5.1 Summary

This study assessed 185 chest radiographs of road traffic accident patients in Benin City to evaluate the prevalence and pattern of fractures, identify fracture types, document associated radiographic findings, and test their correlation. The results revealed that the middle ribs (4–8) were most frequently fractured, while upper- and lower-rib injuries, though less common, carried clinical significance. Non-displaced fractures were most common, but displaced, comminuted, and segmental patterns were also present, reflecting higher-energy impacts. Associated findings included pneumothorax (22.7%), hemothorax (18.9%), and pulmonary contusion (15.1%), which increased significantly with fracture complexity. Hypothesis testing confirmed that fracture patterns were strongly correlated with these complications ($p < 0.05$).

5.2 Conclusion

Chest X-rays are crucial for the swift assessment of chest injuries resulting from road traffic accidents in Benin City. The research showed that rib fractures are prevalent, and their characteristics and locations can indicate the likelihood of complications. The middle ribs are the most susceptible, while fractures in the upper ribs are indicative of severe trauma, and injuries to the lower ribs may imply concurrent abdominal injuries. Fractures that are displaced, comminuted, or segmental heighten the probability of pneumothorax, hemothorax, and pulmonary contusion. The strong correlation identified between the pattern of fractures and the occurrence of complications reinforces that standard chest X-rays, despite certain limitations, still hold a valuable diagnostic and predictive function in emergency trauma management.

5.3 Recommendations

1. Trauma protocols: Radiographers should be educated to properly document fracture distribution and morphology, which have diagnostic value for complications.
2. Early monitoring: Patients with displaced, comminuted, or segmental fractures should be actively followed for pneumothorax, hemothorax, and pulmonary contusion, even if these symptoms are not immediately obvious.
3. Integration with clinical teams: Radiographic findings should be communicated in detail to trauma teams, ensuring fracture patterns guide both monitoring and intervention strategies.

4. Resource allocation: In settings where CT is not readily available, chest radiography should be used to its fullest potential by using proper patient positioning, additional views, and follow-up films when necessary.

5. Public health response: Given the predominance of RTAs as the cause of chest trauma,

community and government stakeholders should strengthen road safety campaigns and enforcement.

5.3 Limitations

1) The study relied on retrospective review of radiographs, which may be limited by image quality, positioning errors, and incomplete patient data.

2) The absence of CT correlation may have led to under-detection of subtle pulmonary contusions or small pneumothoraces.

3) Clinical outcomes (e.g., mortality, length of hospital stay) were not evaluated, so the prognostic impact of fracture patterns could not be fully established.

5.5 Suggestions for Further Studies

1. Future research should compare chest radiographic findings with CT scans to quantify sensitivity and specificity in detecting complications.

2. Larger multicenter studies within Nigeria would provide broader epidemiological data on chest trauma patterns.

3. Prospective studies could explore the outcomes of patients with different fracture morphologies, focusing on mortality, length of hospital stay, and need for surgical intervention.

4. Investigation into the role of ultrasound in complementing plain radiographs for trauma patients in resource-limited settings is recommended.

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APPENDIX I

HEALTH RESEARCH ETHICS COMMITTEE (HREC)

UNIVERSITY OF BENIN TEACHING HOSPITAL

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Registration Number:
NHREC-UBTH-HREC/24/12/2022B

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/2025/196

PROPOSAL TITLE: **"EVALUATION OF COMMON FRACTURES DETECTED ON CHEST RADIOGRAPH OF ROAD TRAFFIC ACCIDENT PATIENT IN UNIVERSITY OF BENIN TEACHING HOSPITAL, BENIN CITY"**

PRINCIPAL INVESTIGATOR(S): **ANOSIKE SHALOM IJEOMA**

DEPARTMENT/INSTITUTION: **DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE**

DATE CONSIDERED: AUGUST 20TH, 2025

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 20/8/2025 TO 19/8/2026. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI **SIGNATURE & DATE**........ 20/8/2025

SUPERVISOR (S): DR UCHECHUKWU NWADIKE

DECLARATION BY INVESTIGATOR(S):
PROTOCOL NUMBER (please quote in all enquiries)
Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study. In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of your approval and avoid disruption of your research. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit your research site without previous notification

Signature & Date........ 22-08-2025

ubthresearchethics@gmail.com Registration Number: NHREC/24/01/202

APPENDIX II

PATIENT RADIOGRAPHIC DATA EXTRACTION CHECKLIST

Study Title: Prevalence and Pattern of Chest Trauma Injuries Based on Radiographic Findings

S/N	Patient ID/Code	Age	Sex	Date of Imaging	Rib 1 Fracture	Rib 2 Fracture	Rib 3 Fracture	Rib 4 Fracture	Rib 5 Fracture	Rib 6 Fracture	Rib 7 Fracture	Rib 8 Fracture	Rib 9 Fracture	Rib 10 Fracture	Rib 11 Fracture	Rib 12 Fracture	Sternum (Manubrium)	Sternum (Body)	Sternum (Xiphoid)	Clavicle (Right)	Clavicle (Left)	Scapula (Right)	Scapula (Left)	Pneumothorax	Hemothorax	Pulmonary Contusion	Other Findings	Remarks