

CT-Based Radiologic Anatomy in Trauma Assessment: From Head to Toe

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ABSTRACT

Trauma remains one of the leading causes of death and disability worldwide, particularly in regions with high rates of road traffic accidents and limited access to emergency care. In these settings, rapid and accurate diagnosis is crucial for survival. Computed tomography (CT) has emerged as the cornerstone of trauma imaging, with radiologic anatomy landmarks providing the essential roadmap for clinicians to identify life-threatening injuries quickly and decisively. This systematic review, conducted in line with PRISMA 2020 guidelines, analyzed studies published between 2017 and 2025 across PubMed, Scopus, EMBASE, Cochrane Library, and Google Scholar. The evidence demonstrates that radiologic anatomy landmarks enhance CT interpretation across all trauma regions: midline structures and basal cisterns in head injuries, the carina and aortic arch in thoracic trauma, hepatic fissures and peritoneal recesses in abdominal injuries, and pelvic ring alignment in pelvic fractures. Whole-body CT (WBCT) provides a comprehensive overview in polytrauma, reducing missed injuries and improving multidisciplinary teamwork, though radiation exposure and incidental findings remain important limitations. The CT-based radiologic anatomy is not just a diagnostic tool but a lifeline in modern trauma care, improving precision, speeding decision-making, and supporting life-saving interventions. Future directions include AI-assisted landmark recognition and standardized reporting frameworks to further optimize trauma imaging and patient outcomes.

Keywords: Computed Tomography, Artificial Intelligence, X-Ray, Whole-Body CT.

INTRODUCTION

Trauma continues to be one of the most pressing global health challenges, claiming countless lives each year and leaving many more with long-term disabilities. The burden is especially heavy in regions where road traffic accidents are common and access to advanced emergency care is limited. In these high-stakes situations, time is critical: the faster injuries are identified, the greater the chance of survival [1].

Computed tomography (CT) has transformed trauma care by offering rapid, detailed visualization of internal injuries that may not be apparent during clinical examination. Unlike traditional radiography, CT can assess multiple anatomical regions within minutes, making it

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indispensable in emergency departments. From detecting intracranial hemorrhage and skull fractures in neurotrauma, to identifying pneumothorax, hemothorax, and aortic injury in thoracic trauma, CT provides clinicians with the clarity needed to act decisively [2].

The true power of CT lies in its reliance on radiologic anatomy landmarks. These landmarks serve as diagnostic signposts, guiding clinicians to recognize subtle but life-threatening changes across the head, chest, abdomen, pelvis, and spine. In polytrauma cases, whole-body CT (WBCT) often referred to as the “trauma pan-scan” has become a cornerstone of modern practice, enabling comprehensive assessment in a single scan and reducing the risk of missed injuries [3].

At the same time, CT protocols must be carefully tailored to patient populations, particularly children, where radiation sensitivity and sedation requirements demand special consideration. The evolution of structured imaging protocols and landmark-guided interpretation has not only improved diagnostic accuracy but also strengthened communication among radiologists, surgeons, and emergency physicians, ensuring that life-saving decisions are made quickly and collaboratively [4].

This review explores the role of radiologic anatomy in CT-based trauma assessment from head to toe. By examining how anatomical landmarks shape interpretation across different regions of the body, it highlights the ways in which CT has revolutionized trauma care, while also considering its limitations and future directions [5-7].

LITERATURE REVIEW

Over the past six years, radiologic anatomy has increasingly been recognized as the backbone of modern trauma imaging, guiding clinicians not only in identifying injuries but in making time-critical decisions during resuscitation. With the widespread adoption of whole-body computed tomography (WBCT), anatomical landmarks have evolved from passive descriptors to active diagnostic tools that shape interpretation pathways across neurotrauma, thoracic emergencies, abdominal injuries, pelvic fractures, and polytrauma assessment. This shift is reflected throughout contemporary trauma literature, where the precision and speed afforded by landmark-guided CT interpretation are repeatedly emphasized.

In neurotrauma, cranial CT remains essential for identifying intracranial hemorrhage, midline shift, and herniation patterns. Accurate interpretation heavily depends on recognizing midline structures such as the falx cerebri, septum pellucidum, and basal cisterns. Studies demonstrate that early recognition of basal cistern effacement or deviation of the septum pellucidum improves detection of mass effect

and diffuse axonal injury, ultimately influencing neurosurgical intervention and outcomes [8,9]. CT angiography further builds on anatomical vascular landmarks particularly the Circle of Willis and petrous carotid canal to identify traumatic cerebrovascular injuries, a frequently underdiagnosed yet life-threatening complication in severe head trauma [10].

Thoracic trauma CT interpretation likewise relies on anatomical fidelity. The aortic arch contour, carina, trachea, and costophrenic angles serve as key landmarks for detecting aortic injury, massive hemothorax, pneumothorax, and tracheobronchial disruption [11,12]. Even subtle variations, such as tracheal deviation or bronchial splaying, can signal underlying injuries missed on radiographs, particularly in high-energy blunt trauma [13]. Alignment of thoracic vertebrae and integrity of the scapular borders also provide critical indicators of thoracic spine instability, which may coexist with rib fractures or sternoclavicular injuries.

In abdominal trauma, CT has become the gold standard for assessing solid organ injury, bowel compromise, and vascular disruption in hemodynamically stable patients. Anatomical landmarks such as hepatic fissures, renal pelvis orientation, arterial branches, and peritoneal reflections guide detection of lacerations, contusions, active bleeding, and mesenteric tears [14]. The importance of evaluating anatomical recesses like Morrison's pouch, the splenorenal recess, and rectovesical /rectouterine spaces has been highlighted in studies demonstrating that these dependent spaces often reveal early or subtle signs of haemorrhage [15-17]. Recognition of bowel injury frequently relies on smaller anatomical clues such as mesenteric stranding, focal bowel wall thickening, and disruptions along the duodenal C-loop, underscoring the value of landmark-based interpretation in avoiding missed injuries [18].

Musculoskeletal and pelvic trauma further demonstrate the clinical utility of landmark-guided radiologic assessment. Pelvic CT evaluation depends on reference points including the pubic symphysis, sacroiliac joints, acetabular arcs, and sacral foramina. Studies show that systematic evaluation of pelvic ring alignment significantly improves detection of rotational instability, vertical shear injuries, and occult sacroiliac disruptions particularly important in polytrauma where pelvic bleeding is a major cause of mortality [19]. Similarly, CT of the spine utilizes vertebral body height, facet joint orientation, pedicle symmetry, and spinal canal dimensions to diagnose fractures, ligamentous injury, and potential instability [20].

More recently, computational imaging research has highlighted the importance of anatomical landmarks in training artificial intelligence (AI) models for trauma CT interpretation. Deep learning systems that incorporate

anatomical guidance demonstrate higher accuracy in detecting intracranial hemorrhage, fractures, and organ injury compared to unguided models [21,22]. These landmark-aware algorithms not only improve diagnostic performance but also enhance interpretability, a vital factor for clinical adoption. Large-scale initiatives such as the RSNA and MIDRC datasets increasingly emphasize standardized anatomical labeling, which improves model generalization and supports reproducible trauma analysis [23].

Radiologic anatomy also forms the core of structured trauma reporting frameworks. Standardized CT reporting organized by anatomical regions and guided by landmarks has been shown to improve communication between radiologists, trauma surgeons, and emergency physicians, especially during high-pressure resuscitation and handovers. Enhanced consistency in reporting improves accuracy in injury severity scoring and reduces diagnostic omissions during polytrauma evaluation [24].

Overall, contemporary evidence demonstrates that radiologic anatomy is not a static knowledge area but a dynamic, clinically indispensable tool. Across neurotrauma, thoracic emergencies, abdominal injuries, and complex pelvic and spinal trauma, anatomical landmarks provide the structure, precision, and clarity required for rapid, life-saving diagnosis. As trauma imaging continues to advance, particularly with the integration of AI and standardized reporting, the central role of radiologic anatomy remains more critical than ever.

MATERIALS AND METHODS

To investigate how anatomical landmarks, support trauma assessment across the body in CT imaging, this systematic review followed the principles outlined in the PRISMA 2020 guidelines, which offer a robust framework for ensuring transparency and reproducibility. The review was structured to explore studies that emphasize the role of radiologic anatomy in emergency CT protocols from the head down to the musculoskeletal system.

A thorough literature search was carried out across five major databases: PubMed, Scopus, EMBASE, Cochrane Library, and Google Scholar. The search process included both MeSH terms and free-text keywords like radiologic anatomy, anatomical landmarks, trauma CT, whole-body CT, and terms related to specific systems such as cranial, thoracic, abdominal, and musculoskeletal. Boolean operators and truncation tools were adjusted across platforms to increase search sensitivity. Only studies published from January 2017 through May 2025 were considered eligible. The search was last updated in June 2025 to ensure the inclusion of the most current data and recommendations.

In selecting the articles for this review, we aimed to balance scientific rigor with clinical relevance. To that end, the following criteria guided the screening process:

Inclusion criteria

- I. Peer-reviewed articles published in English between 2017 and 2025
- II. Original studies, systematic reviews, or clinical guidelines involving human trauma patients
- III. Explicit focus on CT-based trauma imaging involving anatomical landmarks in at least one of the following systems: cranial, thoracic, abdominal, or musculoskeletal

Exclusion criteria

- I. Articles not published in English
- II. Case reports involving fewer than five subjects
- III. Studies based solely on animal models or cadaveric research with no clear clinical correlation
- IV. Abstract-only records, opinion pieces, or grey literature without peer review
- V. Imaging studies that did not involve CT as a modality or did not clearly emphasize anatomical landmarks.

Search results were first imported into Zotero for automatic de-duplication. After that, title and abstract screening were independently carried out by two reviewers using Rayyan.ai, an AI-powered collaborative screening platform. When abstracts lacked clarity, full texts were retrieved to determine eligibility. Any disagreements in article inclusion were discussed and resolved by consensus, involving a third reviewer when necessary.

A standardized data extraction table was designed in Microsoft Excel to collect key information from each included article. Extracted variables included author names, publication year, the anatomical system assessed, CT protocol type (e.g., WBCT, focused CT), specific landmarks discussed, diagnostic value, and clinical relevance. Each article was reviewed in full to extract detailed anatomical insights and contextual findings, and the extracted data were cross-validated between reviewers to maintain accuracy and consistency.

Recognizing the variability in research designs and trauma scenarios, we employed a qualitative synthesis rather than a meta-analysis. Risk of bias for each included study was assessed using study-appropriate tools: QUADAS-2 for diagnostic imaging studies and AMSTAR-2 for any included systematic reviews. The overall certainty of evidence was gauged using the GRADE framework where applicable. Rather than comparing numerical outcomes across studies,

we focused on extracting patterns in how anatomical landmarks were described, interpreted, and applied within trauma imaging settings.

DISCUSSION AND CONCLUSION

Radiologic anatomy has truly changed the way trauma is assessed in emergency care. With the rise of whole-body CT (WBCT), clinicians now have the ability to see injuries across the head, chest, abdomen, pelvis, and spine in one continuous scan. This has transformed the early resuscitation phase, where every second counts. Instead of piecing together fragmented information from different imaging studies, WBCT provides a single, unified picture that helps doctors act quickly and confidently [25,26].

That said, the evidence shows a more nuanced reality. Observational studies suggested that WBCT improved survival in severely injured patients, but large trials such as REACT-2 revealed that while WBCT speeds up diagnosis, it does not automatically reduce mortality compared to selective CT. This means its greatest value lies in workflow efficiency and in giving clinicians a clear anatomical roadmap, rather than being a guaranteed survival tool on its own. In practice, WBCT is most beneficial when patients have high-energy injuries, reduced consciousness, or unreliable clinical examinations situations where missing an injury could be catastrophic [27].

The diagnostic advantages are undeniable. CT consistently outperforms plain radiography, especially in detecting subtle fractures, vascular injuries, and hidden bleeding. For example, CT can identify cervical spine injuries with nearly double the sensitivity of X-ray. Landmark-guided interpretation makes this even stronger: midline structures in the brain, the carina in the chest, peritoneal recesses in the abdomen, and pelvic ring alignment all serve as “signposts”

that guide radiologists to injuries that might otherwise be overlooked [28].

WBCT is not without challenges such as Radiation exposure remains a serious concern, particularly for children and young adults. Incidental findings are another issue CT often uncovers abnormalities unrelated to trauma, which can lead to unnecessary tests, anxiety, and added costs. These realities remind us that WBCT should be used thoughtfully, not indiscriminately. Selective imaging remains appropriate for patients with isolated or low-energy injuries.

On the positive side, WBCT has improved teamwork in trauma care. By offering a complete anatomical overview, it allows radiologists, surgeons, and emergency physicians to coordinate more effectively. This shared view reduces delays and ensures that critical decisions are made with the full picture in mind.

Looking forward, technology promises to take trauma imaging even further. Artificial intelligence (AI) systems trained to recognize anatomical landmarks are already showing improved accuracy in detecting hemorrhage, fractures, and organ injuries. Standardized reporting frameworks are also helping reduce diagnostic omissions and improve communication during handovers. Together, these innovations point toward a future where trauma imaging is faster, more precise, and more reliable.

In summary, WBCT and landmark-guided CT interpretation represent a major step forward in trauma care. Their strength lies in providing clarity and speed when patients need it most. While survival benefits depend on patient selection, the ability to see the whole picture, avoid missed injuries, and support coordinated care makes CT-based radiologic anatomy an indispensable tool in modern emergency medicine [29].

Key Anatomical Landmarks in Trauma CT Evaluation

Trauma Region	Key Anatomical Landmarks	Diagnostic Utility
Head / Neurotrauma	Falx cerebri, septum pellucidum, basal cisterns, Circle of Willis	Detects midline shift, herniation, intracranial hemorrhage, diffuse axonal injury, and traumatic cerebrovascular injury
Chest / Thoracic Trauma	Aortic arch contour, carina, trachea, costophrenic angles, scapular borders	Identifies aortic injury, pneumothorax, hemothorax, pulmonary contusions, tracheobronchial disruption, thoracic spine instability
Abdomen	Hepatic fissures, renal pelvis orientation, arterial branches, Morrison's pouch, splenorenal recess, rectovesical/rectouterine spaces	Guides detection of liver/splenic lacerations, renal injury, bowel perforation, mesenteric tears, and early hemorrhage
Pelvis	Pubic symphysis, sacroiliac joints, acetabular arcs, sacral foramina, pelvic ring alignment	Assesses rotational instability, vertical shear injuries, occult sacroiliac disruptions, and pelvic bleeding
Spine	Vertebral body height, facet joint orientation, pedicle symmetry, spinal canal dimensions	Detects fractures, subluxations, ligamentous injury, canal narrowing, and potential instability

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