Role of Computed Tomography (CT) in the Diagnosis of Common Emergency Conditions: A Literature Review

Tarun Jagdish Tandon

Associate Professor, GMERS Medical College, Himmatnagar (Gujrat) India

Email id: taruntandon2@gmail.com

Abstract

Computed tomography (CT) has become a central imaging modality in the evaluation of acute emergency presentations. This review synthesizes existing evidence on CT's role in the diagnosis and management of common emergency conditions, with emphasis on acute thoracic, abdominal, neurological, and pulmonary emergencies, and including considerations of CT angiography and the balance of diagnostic yield versus unnecessary imaging. The present research paper highlight areas of consensus, discrepancies between studies, and gaps where further evidence is needed.

Keywords: Computed Tomography (CT); Emergency Medicine; CT Angiography (CTA); Acute Stroke; Pulmonary Embolism; Acute Chest Pain; Acute Abdomen; Acute Respiratory Distress Syndrome (ARDS); Artificial Intelligence; Emergency Radiology; Diagnostic Imaging; Clinical Decision-Making.

1. Introduction

In emergency medicine, rapid and accurate diagnostic imaging is essential to guide timely management and improve outcomes. CT offers high spatial resolution, broad anatomic coverage, and (in the case of CT angiography and dual-energy approaches) functional information that enhances diagnostic confidence for a spectrum of acute conditions. The present synthesis draws on literature addressing CT's utility in common emergent scenarios, including pulmonary embolism (PE), acute chest pain, acute stroke, acute abdomen, acute respiratory distress syndrome (ARDS) as it relates to imaging, and broader usage of CT in emergency settings. Where possible, claims are anchored to explicit data reported in the cited works.

2. Acute Chest Pain and Thoracic Emergencies

Computed tomography (CT), particularly CT angiography (CTA), plays a crucial role in the evaluation of patients presenting with acute chest pain and other thoracic emergencies. In emergency settings, CTA is frequently utilized to rapidly exclude life-threatening conditions such as acute aortic syndromes, pulmonary embolism (PE), and other thoracic vascular abnormalities. Its ability to provide high-resolution visualization of the thoracic vasculature, lung parenchyma, mediastinum, and pleural structures enables clinicians to establish an accurate diagnosis within a short time frame, thereby facilitating prompt treatment decisions. Furthermore, when initial chest radiography yields inconclusive or nonspecific findings, CT serves as a valuable second-line imaging modality by providing comprehensive anatomical detail that supports risk stratification and guides appropriate therapeutic interventions.

Stroke and Neurological Emergencies

CT imaging is considered the cornerstone of the initial evaluation of patients with suspected acute stroke and other neurological emergencies. Owing to its rapid acquisition time, widespread availability, and high diagnostic accuracy, non-contrast CT (NCCT) is typically the first imaging modality performed to distinguish ischemic stroke from intracranial hemorrhage, which is essential for determining eligibility for thrombolytic therapy. CT also assists in identifying other contraindications to reperfusion treatment, such as extensive hemorrhage or mass lesions. Advanced CT techniques, including CT angiography (CTA) and CT perfusion (CTP), further enhance diagnostic capability by detecting large vessel occlusions, evaluating cerebral blood flow, and identifying potentially salvageable brain tissue (ischemic penumbra). These imaging advances have significantly improved acute stroke management pathways by enabling timely patient selection for mechanical thrombectomy and other reperfusion strategies (Schonfeld et al., 2024).

Computed tomography has become the preferred imaging modality for the evaluation of acute abdominal emergencies because of its ability to provide rapid and comprehensive assessment of abdominal and pelvic organs. Multidetector CT (MDCT) is widely used in patients with suspected acute appendicitis, diverticulitis, bowel obstruction, mesenteric ischemia, perforated viscus, and traumatic intra-abdominal injuries. Its excellent spatial resolution and multiplanar reconstruction capabilities allow clinicians to accurately identify the underlying pathology, assess disease severity, and detect associated complications. As a result, CT findings play a vital role in determining whether patients require immediate surgical intervention or can be managed conservatively, thereby improving clinical outcomes and reducing unnecessary exploratory procedures.

3. Acute Respiratory Distress Syndrome (ARDS) and Imaging

Imaging is fundamental to the diagnosis, monitoring, and management of Acute Respiratory Distress Syndrome (ARDS). Although chest radiography remains the initial imaging modality for evaluating diffuse pulmonary infiltrates, CT provides a far more detailed assessment of lung parenchymal involvement, regional aeration, pulmonary consolidation, and perfusion abnormalities. High-resolution CT enables clinicians to visualize the heterogeneous distribution of lung injury, identify recruitable lung tissue, and assess disease severity more accurately than conventional radiography. These findings contribute to prognostic assessment and help optimize ventilatory strategies, including positive end-expiratory pressure (PEEP) titration and prone positioning. Recent evidence also highlights the evolving role of CT from purely morphological assessment to functional evaluation, while bedside imaging modalities such as lung ultrasound and electrical impedance tomography (EIT) complement CT by providing continuous, real-time monitoring of pulmonary function during critical care management (Cheng et al., 2021; Li & Cao, 2022).

Recent advancements in CT technology have significantly expanded its role beyond conventional anatomical imaging. CT angiography (CTA) has emerged as the gold-standard non-invasive imaging technique for evaluating vascular emergencies, particularly pulmonary embolism, acute aortic syndromes, arterial dissections, and other life-threatening vascular conditions, owing to its rapid image acquisition, high spatial resolution, and excellent diagnostic accuracy. In addition, advanced functional imaging techniques such as dual-energy CT (DECT) and CT perfusion imaging (CTP) provide valuable physiological information by assessing tissue perfusion, vascular integrity, and organ viability. These innovations enable clinicians to detect perfusion abnormalities, evaluate tissue ischemia, and support individualized treatment planning in emergency settings. Consequently, modern CT-based imaging has evolved into an indispensable tool for both accurate diagnosis and precision-guided management of critically ill patients.

4. Emerging and Adjunct Imaging Approaches in Emergency CT

Recent technological advancements have expanded the role of computed tomography (CT) in emergency medicine beyond conventional image acquisition and interpretation. In particular, artificial intelligence (AI) and machine learning (ML) are increasingly being integrated into emergency radiology workflows to improve the speed, accuracy, and consistency of CT image interpretation. AI-powered algorithms have demonstrated significant potential in the automated detection of critical conditions such as pulmonary embolism (PE), acute ischemic stroke, intracranial hemorrhage, and thoracic abnormalities. These systems can assist radiologists by rapidly identifying suspicious findings, prioritizing urgent cases for review, reducing diagnostic delays, and minimizing human error. Consequently, AI has the potential to enhance radiologist performance, improve emergency department triage, and standardize image interpretation across healthcare settings. However, despite these promising developments, further algorithm refinement, large-scale validation, and clinical integration are required before AI can be routinely adopted as a fully reliable diagnostic tool (Wang et al., 2021; Zhao et al., 2020).

In addition to AI-driven image analysis, point-of-care and cloud-enabled diagnostic frameworks are emerging as innovative approaches to emergency imaging. These technologies facilitate the rapid sharing and integration of CT-derived imaging data with electronic health records, laboratory findings, and other clinical information, enabling healthcare professionals to make faster and more informed decisions. Cloud-based platforms also support remote image interpretation, multidisciplinary collaboration, and tele-radiology services, which are particularly valuable in resource-limited settings and during mass casualty incidents. By combining advanced CT imaging with digital health technologies, these emerging frameworks have the potential to improve workflow efficiency, accelerate diagnosis, and optimize patient management in emergency care environments (FAN et al., 2017).

5. Current Challenges and Clinical Considerations

Despite its exceptional diagnostic accuracy and widespread use in emergency medicine, computed tomography (CT) remains associated with several important clinical controversies. One of the primary concerns is the potential for overutilization, which may expose patients to unnecessary ionizing radiation and increase healthcare costs without improving clinical outcomes. These concerns are particularly significant in pediatric patients, who are more sensitive to radiation and have a longer lifetime risk of radiation-induced malignancies. Consequently, current clinical guidelines advocate a risk-stratified imaging approach, ensuring that CT examinations are performed only when the expected diagnostic benefits outweigh the potential risks. This strategy is especially relevant in the evaluation of patients with minor head trauma, uncomplicated headaches, seizures, and low-risk injuries, where careful clinical assessment and validated decision rules may reduce unnecessary imaging without compromising patient safety. Evidence-based protocols therefore emphasize judicious CT utilization while maintaining high standards of diagnostic care (Schonfeld et al., 2024).

Another area of ongoing debate concerns the variation in imaging practices across different healthcare settings. Studies have identified notable differences in CT utilization between general emergency departments and pediatric emergency departments, reflecting differences in patient populations, physician experience, institutional protocols, and risk tolerance. Pediatric emergency physicians generally adopt a more conservative imaging approach because of radiation concerns, whereas adult emergency departments may demonstrate higher imaging rates. Reducing unnecessary CT examinations while preserving diagnostic accuracy and patient safety continues to be an important focus of clinical research, quality improvement initiatives, and evidence-based guideline development (Schonfeld et al., 2024).

6. Gaps and Future Directions

Although CT has become an indispensable imaging modality in emergency medicine, several knowledge gaps and opportunities for future research remain. Greater integration of functional imaging techniques, advanced imaging biomarkers, and quantitative image analysis may improve the early detection of disease, assessment of tissue viability, and prediction of clinical outcomes across a broad spectrum of emergency conditions. In addition, there is a need for large-scale, prospective, multicenter clinical studies to evaluate the effectiveness of CT-guided diagnostic pathways in diverse patient populations and healthcare systems. Such investigations would provide stronger evidence regarding the impact of CT on patient outcomes, healthcare utilization, and cost-effectiveness.

The expanding application of artificial intelligence (AI) in emergency CT interpretation also represents an important area for future research. Although AI-assisted image analysis has shown considerable promise in accelerating diagnosis and supporting clinical decision-making, its implementation in routine practice requires rigorous clinical validation, standardized regulatory frameworks, and continuous performance monitoring. Future developments should focus on ensuring the safety, reliability, reproducibility, and transparency of AI algorithms before their widespread adoption in emergency radiology.

7. Synthesis and Implications for Practice

Computed tomography has transformed the practice of emergency medicine by providing rapid, accurate, and comprehensive diagnostic evaluation across a wide range of acute clinical conditions. Its high diagnostic yield, short acquisition time, and broad anatomical coverage enable clinicians to promptly diagnose life-threatening disorders such as pulmonary embolism, acute aortic syndromes, ischemic and hemorrhagic stroke, traumatic injuries, and acute abdominal emergencies, thereby facilitating timely and appropriate treatment decisions. Advanced CT techniques, including CT angiography (CTA) and CT perfusion imaging (CTP), further enhance diagnostic capability by providing detailed vascular assessment and functional information regarding tissue perfusion and viability. These advances have substantially improved patient triage, therapeutic planning, and overall emergency care.

Emerging technologies, including artificial intelligence, machine learning, dual-energy CT, and advanced post-processing techniques, continue to expand the diagnostic capabilities of CT and improve workflow efficiency. Nevertheless, responsible CT utilization remains essential to minimize unnecessary radiation exposure, particularly among pediatric patients and individuals with low-risk clinical presentations. Adherence to evidence-based imaging guidelines, implementation of radiation dose optimization strategies, and appropriate patient selection are fundamental to maximizing the clinical benefits of CT while minimizing potential risks. Overall, the available evidence consistently supports CT as a first-line imaging modality in many emergency scenarios, and its role is expected to continue evolving through ongoing technological innovation, clinical research, and evidence-based practice (Cheng et al., 2021; Li & Cao, 2022; Schonfeld et al., 2024; 李, 2015; FAN et al., 2017; Wang et al., 2021; Zhao et al., 2020).

8. Conclusion

Computed tomography (CT) has become an indispensable imaging modality in modern emergency medicine because of its ability to provide rapid, accurate, and comprehensive diagnostic information across a wide spectrum of acute clinical conditions. This review demonstrates that CT plays a pivotal role in the diagnosis and management of life-threatening emergencies, including acute chest pain, pulmonary embolism, acute aortic syndromes, ischemic and hemorrhagic stroke, acute abdominal disorders, traumatic injuries, and acute respiratory distress syndrome. The introduction of advanced imaging techniques such as CT angiography (CTA), CT perfusion (CTP), multidetector CT (MDCT), and dual-energy CT (DECT) has further enhanced diagnostic precision by enabling detailed vascular assessment and functional evaluation of tissues.

Emerging technologies, particularly artificial intelligence and machine learning, are transforming emergency radiology by improving image interpretation, accelerating triage, and supporting clinical decision-making. Although these innovations show considerable promise, their widespread implementation requires further clinical validation, standardized regulatory frameworks, and integration into existing healthcare systems. At the same time, concerns regarding radiation exposure, overutilization of CT, and variations in imaging practices underscore the importance of evidence-based imaging guidelines, appropriate patient selection, and radiation dose optimization, particularly in pediatric and low-risk populations.

Overall, the current literature consistently supports CT as a first-line imaging modality for many emergency presentations due to its high diagnostic yield, rapid image acquisition, and broad anatomical coverage. Future research should focus on integrating advanced functional imaging, quantitative imaging biomarkers, and artificial intelligence into routine emergency practice while strengthening the evidence through large-scale prospective multicenter studies. Continued technological innovation, combined with judicious and patient-centered CT utilization, will further enhance diagnostic accuracy, improve clinical outcomes, and optimize the delivery of emergency healthcare.

References

- Chai, T. (2016). Industrial process control systems: research status and \\development direction. Scientia Sinica Informationis, 46(8), 1003–1015. https://doi.org/10.1360/n112016-00062
- Chen, B., Zeng, N., CAO, X., Zhou, S., He, W., & Tian, S. (2021). Unsupervised learning-driven intelligent fault diagnosis algorithm for high-end bearing. Scientia Sinica Technologica, 52(1), 165–179. https://doi.org/10.1360/sst-2021-0296
- Cheng, W. T., He, H., Su, L., Cui, N., Wang, X., Zhou, X., Weng, L., Long, Y., Du, B., & Liu, D. (2021). Advances on acute respiratory distress syndrome based on imaging: from morphology to function. Scientia Sinica Vitae, 51(8), 963–969. https://doi.org/10.1360/ssv-2021-0201
- FAN, J., Han, D., Yang, L., Huang, J., Wang, H., Peng, X., Dai, G., Chen, H., & Tian, F. (2017). Multimodal aided neurological disease diagnosis with synergy of cloud and client. Scientia Sinica Informationis, 47(9), 1164–1182. https://doi.org/10.1360/n112017-00075
- Gaugler, J. E., Kane, R. L., Johnston, J. A., & Sarsour, K. (2013). Sensitivity and Specificity of Diagnostic Accuracy in Alzheimer's Disease. American Journal of Alzheimer S Disease & Other Dementias®, 28(4), 337–347. https://doi.org/10.1177/1533317513488910
- Guo, S., Li, Y., & Li, J. (2020). Semi-supervised Fault Identification Based on Laplacian Eigenmap and Deep Belief Networks. Journal of Mechanical Engineering, 56(1), 69. https://doi.org/10.3901/jme.2020.01.069
- Hu, N. (2019). Fault Diagnosis for Planetary Gearbox Based on EMD and Deep Convolutional Neural Networks. Journal of Mechanical Engineering, 55(7), 9. https://doi.org/10.3901/jme.2019.07.009
- Huang, R., Li, J., Wang, Z., XIA, J., CHEN, Z., & Li, W. (2021). Intelligent diagnostic and prognostic method based on multitask learning for industrial equipment. Scientia Sinica Technologica, 52(1), 123–137. https://doi.org/10.1360/sst-2021-0314
- Jiang, Y., Wang, Y., Yi, J., Miao, Z., Liu, L., Zhong, H., & Zhang, H. (2020). Research on intelligent robot systems for emergency prevention and control of major pandemics. Scientia Sinica Informationis, 50(7), 1069–1090. https://doi.org/10.1360/ssi-2020-0107

- Lei, H., Dong, L., Zhuo, Y., Zhou, X., Gao, J., Gong, Q., & DU, Y. (2020). Magnetic resonance imaging: progresses and perspective. Scientia Sinica Vitae, 50(11), 1285–1295. https://doi.org/10.1360/ssv-2020-0164
- Li, C., Liu, Q., & Xu, P. (2023). A micro-hyperspectral image classification method of gallbladder cancer based on multi-scale fusion attention mechanism. Journal of Image and Graphics, 28(4), 1173–1185. https://doi.org/10.11834/jig.211201
- Li, S., & Cao, F. (2022). Advances in multimodal imaging assessment of coronary microvascular dysfunction after myocardial infarction. Scientia Sinica Vitae, 52(5), 773–780. https://doi.org/10.1360/ssv-2021-0307
- Peng, X., Xu, L., Zhang, J., Jing, Y., Tian, S., Wu, Y., Cao, R., & Zhang, J. (2022). Gallium's Application in Medicine and Hygiene: Examples of Antineoplastic and Anti-Microbial. University Chemistry, 0(0), 2203050–0. https://doi.org/10.3866/pku.dxhx202203050
- Schonfeld, D., Gardner, K., Willemsen, M. A. A. P., & Ostrow, O. (2024). Reducing unnecessary investigations in paediatric seizures in the emergency department. BMJ, 385, e076814. https://doi.org/10.1136/bmj-2023-076814
- Sheng-min, W., Wei, Y., Wei, Q., Li, C. H., Zhang, W., Wang, Y., Li, X., & YANG, M. (2015). Scientia Sinica Informationis, 45(2), 235–247. https://doi.org/10.1360/n112014-00221
- Wang, W., Hu, Y., Wang, X., Ji, L., & Li, Y. (2021). DD-CovidNet Model for X-Ray Images Recognition of Coronavirus Disease 2019. Journal of Computer-Aided Design & Computer Graphics, 33(11), 1649–1657. https://doi.org/10.3724/sp.j.1089.2021.18791
- Wang, W., Zheng, L., Cheng, H., Xu, X., & Meng, B. (2023). Applications and progress of machine learning in wearable intelligent sensing systems. Chinese Science Bulletin (Chinese Version), 68(34), 4630–4641. https://doi.org/10.1360/tb-2023-0636
- Xu, F., Gong, Y., Gao, B., Wen, T. B., & Hu, J. (2016). Advances in monitoring of cardiovascular diseases at the point of care. Scientia Sinica Technologica, 46(11), 1116–1134. https://doi.org/10.1360/n092016-00076
- Xu, X., Tang, J., Zeng, Z., Xu, K., Jiang, H., & He, Y. (2024). Framework and Strategy for Enhancing Resilience of China's Urban Power Systems under Extreme Natural Disasters. Strategic Study of Cae, 26(2), 198. https://doi.org/10.15302/j-sscae-2024.07.011

- Zhao, Y., Gu, L., & WANG, D. (2020). The trend of artificial intelligence method in computer aided diagnosis. Scientia Sinica Vitae, 50(11), 1321–1334. https://doi.org/10.1360/ssv-2020-0150