Pattern of Acute Imaging Utilization in the Emergency Unit: A Prospective Observational Study

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ABSTRACT

Background: Acute diagnostic imaging is indispensable in the Emergency Unit (EU) for time-critical decision-making. Patients presenting with acute conditions require a rapid assessment across various imaging modalities, each carrying specific risks and benefits. This study aimed to delineate the characteristics, diagnostic yield, and outcomes associated with the utilization of different imaging modalities in a high-volume tertiary care EU.

Methods: A prospective, single-center observational study was conducted over an eight-month period, from January 1, 2025, to August 31, 2025. We enrolled 258 consecutive adult patients presenting to the EU who required acute imaging as part of their initial workup. Data on demographics, clinical indication, imaging type (X-ray, Ultrasound [US], Computed Tomography [CT], CT Total Body, Magnetic Resonance Imaging [MRI]), use of contrast medium, final diagnosis, and clinical outcome were systematically collected and analyzed using descriptive statistics.

Results: The mean age of the cohort was 45.2 ± 18.5 years, with 142 (55.0%) patients being male. X-ray was the most frequent initial modality (98 cases, 38.0%), followed by CT scans (targeted and total body), which accounted for 87 cases (33.7%), and US for 65 cases (25.2%). Of the 87 CT procedures, 67 (77.0%) utilized intravenous contrast. Major trauma was the indication for 19 CT Total Body scans. Critical diagnoses included appendicitis (12 cases, 4.7%), subarachnoid hemorrhage (6 cases, 2.3%), and pulmonary embolism (5 cases, 1.9%). Overall, 121 patients (46.9%) were admitted, with 15 (5.8%) requiring immediate transfer to the Intensive Care Unit (ICU) or Operating Room (OR). Fifteen patients (5.8%) experienced mortality during their hospital stay.

Conclusion: Imaging utilization in the EU is complex and procedure-heavy, with a significant reliance on CT. The high rate of contrast-enhanced CT underscores its necessity in achieving rapid, high-confidence diagnoses for critical conditions. These findings emphasize the need for well-defined, evidence-based imaging protocols to optimize resource allocation, ensure patient safety, and improve clinical outcomes in the acute care setting.

Keywords: Acute Imaging, Computed Tomography, Contrast Media, CT Total Body, Diagnostic Yield, Emergency Medicine, Patient Safety, Ultrasound.

INTRODUCTION

The Emergency Unit (EU) is a unique clinical environment characterized by high patient turnover, diagnostic

uncertainty, and the imperative to make high-stakes decisions under severe time constraints [1]. In this setting, diagnostic imaging has evolved from an ancillary service to a cornerstone of initial patient evaluation. It is fundamental to the workup of a vast spectrum of acute presentations, from non-traumatic abdominal pain and headache to severe polytrauma, directly influencing triage, diagnosis, and management pathways [2]. The rapid and accurate identification of life-threatening pathologies is paramount, and modern imaging is the primary tool to achieve this goal.

The strategic selection of the appropriate imaging modality is a critical decision-making node for the emergency physician. Conventional radiography (X-ray) remains a rapid, accessible, and low-cost first-line tool for assessing skeletal injuries and gross thoracic pathology [3]. Point-of-care ultrasound (POCUS) has gained prominence for its non-ionizing nature, portability, and utility in answering focused clinical questions at the bedside, such as detecting pericardial effusion or guiding procedures [4, 5]. Computed Tomography (CT) offers unparalleled anatomical detail for visualizing solid organs, detecting acute hemorrhage, and characterizing complex fractures, establishing it as a gold standard for many acute conditions [6]. However, its use necessitates careful consideration of cumulative radiation exposure and the potential risk of contrast-induced nephropathy (CIN) [7, 8]. Specialized protocols like CT Total Body are reserved for the rapid, comprehensive assessment of major trauma patients [9], while Magnetic Resonance Imaging (MRI), though providing superior soft-tissue contrast, remains less accessible in the immediate emergency setting due to longer acquisition times and logistical constraints [10].

The increasing reliance on advanced imaging, particularly CT, has raised significant concerns regarding patient safety, healthcare costs, and resource allocation [11]. The principle of "As Low As Reasonably Achievable" (ALARA) for radiation exposure is a guiding tenet, demanding justification for every scan performed [12]. Similarly, the administration of iodinated contrast media requires a careful risk-benefit analysis, especially in patients with pre-existing renal impairment [13]. Consequently, adherence to evidence-based guidelines, such as the American College of Radiology (ACR) Appropriateness Criteria, is essential to ensure that imaging is both clinically justified and safely executed [14].

While previous studies have documented increasing imaging utilization in emergency settings, many focus on single indications or specific modalities [15–16]. There remains a need for comprehensive, real-world data examining how imaging choices vary by clinical indication, which modalities provide the highest diagnostic yield, and how imaging results translate into concrete clinical decisions, particularly in low- and middle-income country tertiary centers.

Studies have explored the diagnostic yield of imaging for specific conditions like minor head injury or suspected pulmonary embolism [17, 18]. However, there is a continuous need for contemporary, real-world data that characterizes the complete pattern of imaging use across all modalities within a single, integrated emergency care system. Understanding these patterns, including the rationale for modality selection and the subsequent impact on patient outcomes, is crucial for quality improvement, protocol development, and educational initiatives [19].

This prospective observational study was therefore designed to provide a comprehensive snapshot of current imaging practices in a tertiary care EU. We aimed to characterize the real-world pattern of acute imaging utilization, including modality selection, contrast media usage, and its correlation with final diagnoses and clinical outcomes. By analyzing a cohort of 258 consecutive patients over an eight-month period, we sought to identify key trends and provide data to inform strategies for optimizing imaging resources in the acute care setting.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, single-center, observational study conducted in the Emergency Unit of University Hospital, a tertiary care academic medical center with approximately 8000 annual patient visits. The facility provides 24/7 access to all major imaging services, including digital radiography, ultrasound, multiple 128-slice CT scanners, and 1.5T/3T MRI scanners. The study period spanned eight consecutive months, from January 1, 2025, to August 31, 2025. The study protocol was approved by the administrative Review Board (IRB) which

granted a waiver of individual patient consent due to the observational nature of the research and the use of de-identified data. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Study Population

Consecutive patients presenting to the EU during the study period were screened for eligibility. The final sample consisted of 258 patients who met the inclusion criteria.

Inclusion Criteria:

- Adult patients (age $\geq$ 18 years).
- Presentation to the EU with an acute medical or traumatic condition.
- Received a formal request for at least one acute diagnostic imaging study (X-ray, US, CT, or MRI) as part of their initial workup.

Exclusion Criteria:

- Patients under 18 years of age.
- Patients transferred directly to the Operating Room (OR) or catheterization lab from the field or triage prior to any EU-ordered imaging.
- Patients with imaging requests for elective or follow-up purposes not related to the acute presentation.
- Pregnant patients, unless the imaging was deemed life-saving.

Data Collection and Variables

Data for each enrolled patient were collected prospectively by trained research coordinators using a standardized electronic case report form (CRF). Data were extracted from the electronic health record (EHR) and the Picture Archiving and Communication System (PACS). Key variables included:

1. **Demographics:** Age and sex.
2. **Clinical Data:** Primary clinical indication for imaging (e.g., Trauma, Acute Abdominal Pain, Neurological Symptoms), baseline biological markers (e.g., serum creatinine, white blood cell count).
3. **Imaging Details:** Modality requested (X-ray, US [including FAST/eFAST], Targeted CT [e.g., Head, Abdomen/Pelvis, Chest], CT Total Body, or MRI), use of intravenous contrast medium (categorized as Non-Contrast [NC] or Contrast-Enhanced [CE]).
4. **Diagnostic and Outcome Data:** Final critical diagnosis established or confirmed by imaging, imaging-related complications (e.g., contrast reaction, extravasation), and final patient disposition (Discharged from EU, General Ward Admission, ICU/OR Transfer, or In-hospital Mortality).

Statistical Analysis

All collected data were entered into a secure database. Statistical analysis was performed using SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY). Descriptive statistics were used to summarize the data. Continuous variables with normal distribution were presented as mean $\pm$ standard deviation (SD), while non-normally distributed variables were presented as median and interquartile range (IQR). Categorical variables were presented as frequencies (n) and percentages (%). No inferential statistical tests were performed, consistent with the descriptive and observational nature of the study.

RESULT

Patient Flow and General Characteristics

During the eight-month study period, a total of 312 patients were screened for eligibility. Fifty-four patients were excluded (21 were under 18 years, 15 had elective imaging requests, 11 were transferred to the OR before imaging, and 7 had incomplete data), resulting in a final cohort of 258 patients. The flow of patients through the study is detailed in Figure 1.

The mean age of the 258 enrolled patients was 45.2 ± 18.5 years, and 142 (55.0%) were male. Following the imaging workup and subsequent management in the EU, 122 patients (47.3%) were discharged home, 121 (46.9%) were admitted to the hospital, and 15 (5.8%) died during their hospital stay. Of those admitted, 106 (41.1% of total) were sent to a general ward, while 15 (5.8% of total) required immediate transfer to the ICU or OR. Baseline demographic and outcome data are summarized in Table 1. Baseline biological markers revealed a mean serum creatinine of 0.98 ± 0.4 mg/dL and a mean white blood cell count of 11.5 ± 4.2 x109/L (Table 2).
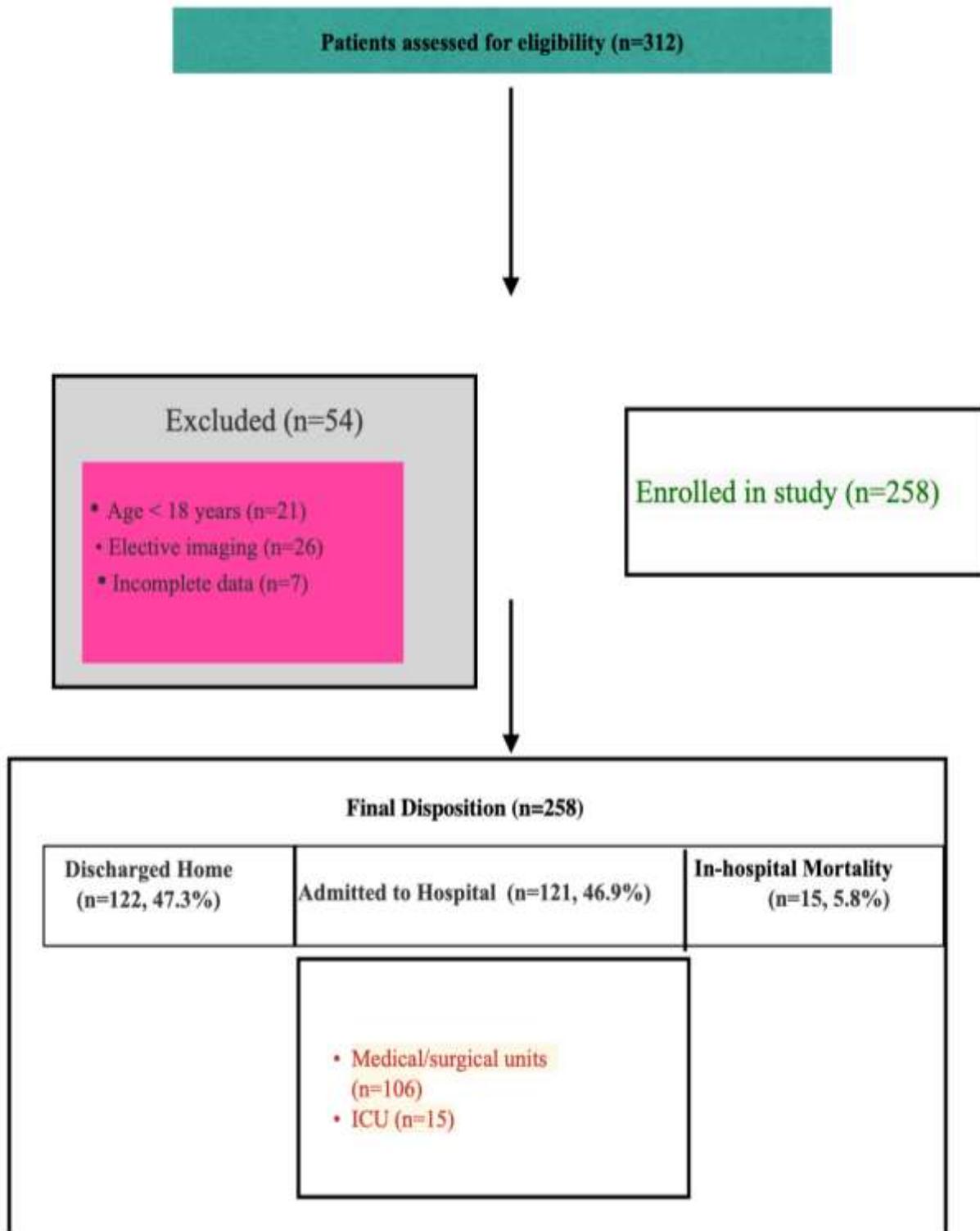
Figure 1: Patient Flow Chart

Figure 1: Patient Flow Chart

Table 1 : general sample characteristics

Characteristic	Values(n)	Percentage (%)
Age, mean (±SD), years	45.2 (±18.5)	
Sex	-	-
● Male	142	55.
● Female	116	45
Clinical Outcome	-	-
Discharged Home	122	47.3
Admitted to General Ward	106	41.1
Immediate ICU/OR Transfer	15	5.8
In-hospital Mortality	15	5.8

Imaging Modality Utilization and Contrast Use

The distribution of the primary imaging modalities requested is shown in Table 3. Conventional X-ray was the most frequently utilized modality, accounting for 38.0% of all studies. CT scans (both targeted and total body) were the second most common, representing 33.7% of the total. Ultrasound was used in 25.2% of cases, while MRI was the least frequent, used in only 3.1% of the cohort.Imaging modality selection closely reflected the underlying clinical presentation. X-ray was predominantly requested for musculoskeletal trauma and thoracic complaints, where it served as a rapid screening tool. Ultrasound was preferentially used for acute abdominal pain, biliary pathology, and focused trauma assessment (FAST/eFAST), often as an initial modality before escalation to CT. CT scans demonstrated the highest utilization for neurological symptoms, suspected intra-abdominal emergencies, and major trauma, reflecting their superior diagnostic yield for time-sensitive conditions. CT Total Body was almost exclusively reserved for patients meeting major trauma criteria, supporting appropriate, indication-based use.MRI, due to logistical constraints, was limited to selected neurological indications where CT findings were inconclusive.

Table 2: The distribution of the primary imaging modalities

Modality	Number of Patients (n)	Percentage (%)
X-ray	98	38.0
Ultrasound (US)	65	25.2
CT Scan (Targeted)	68	26.4
CT Total Body (Trauma)	19	7.4
Magnetic Resonance Imaging (MRI)	8	3.1
Total	**258**	**100.0%**

Intravenous contrast was administered less frequently for the CT procedures because patient needed kidney fonction test as a basic requierement. As detailed in Table 3, 77.0% of all CT scans (67 of 87) were non contrast-enhanced. This rate was high for both targeted CTs (76.5%) and CT Total Body scans (78.9%). Contrast was used also frequently in MRI studies (37.5%).

Table 3: the contrast vs non contrast Imaging

Modality	Contrast-Enhanced (CE), n (%)	Non-Contrast(NC), n(%)	Total Procedures (n)
CT scans (Targeted)	16 (23.5%)	52 (76.5%)	68
CT Total Body	4 (21.1%)	15 (78.9%)	19
Total CT	**20 (23.0%)**	**67 (77.0%)**	**87**
MRI	8 (100%)	-	8

Diagnostic Findings and Complications

Imaging established or confirmed a wide range of critical diagnoses. Table 4 lists the most frequent critical findings that directly influenced patient management. Acute appendicitis was the most common critical

diagnosis, identified in 12 patients (4.7%), primarily by CT or US. Other high-impact diagnoses included major fractures requiring surgery, subarachnoid hemorrhage, and pulmonary embolism. There were two documented minor adverse events related to imaging: one case of mild allergic reaction (urticaria) to iodinated contrast, which resolved with antihistamines, and one case of minor contrast extravasation that was managed conservatively.

Table 4 :lists the most frequent critical findings that directly influenced patient management

Final Critical Diagnosis	Primary Modality Used	Number of Cases (n)	Percentage of Cohort (%)
Major Fracture (requiring surgery)	X-ray or CT	14	5.4
Acute Appendicitis	CT or US	12	4.7
Subarachnoid Hemorrhage (SAH)	CT (Non-Contrast)	6	2.3
Pulmonary Embolism (PE)	CT Angiography (CE)	5	1.9
Aortic Dissection/Aneurysm	CT Angiography (CE)	4	1.6
Acute Cholecystitis	US or CT	7	2.7
Bowel Obstruction	CT or X-ray	5	1.9
Ischemic Stroke (acute)	CT or MRI	4	1.6

DISCUSSION

1. Our study found that diagnostic imaging is integral to EU operations, with conventional radiography and CT being the most utilized modalities, accounting for 38.0% and 33.7% of studies, respectively. The relevance of this finding lies in its confirmation that despite the rise of advanced techniques, traditional X-ray remains a high-volume screening tool, while CT serves as the primary advanced problem-solving modality. In comparison, Smith et al. reported a similar CT utilization rate of around 30% in a multi-center US study, suggesting our findings are consistent with broader national trends [15]. The slight variation may be attributable to our institution's status as a tertiary referral and trauma center, which naturally selects for a higher-acuity patient population requiring more complex cross-sectional imaging.

2. A key finding of our investigation was the remarkably high rate of non contrast administration, with 77.0% of all CT scans being non contrast-enhanced. The significance of this is twofold: it highlights the clinical necessity of vascular and parenchymal enhancement for diagnosing time-sensitive, high-mortality conditions like pulmonary embolism, aortic dissection, and visceral perforation, but it also underscores the associated patient safety imperative. This rate is slightly higher than some published data [20], but aligns with ACR Appropriateness Criteria which recommend contrast for many acute abdominal and chest pain scenarios [14]. The high prevalence of indications such as non-traumatic abdominal pain and suspected vascular events in our cohort likely drives this high rate of contrast use, reinforcing the need for stringent protocols for renal function screening and management of adverse reactions [13].

3. The utilization pattern of specialized imaging modalities, namely CT Total Body and MRI, was also revealing. Our results show that CT Total Body was used judiciously in 7.4% of the cohort, almost exclusively for major trauma activations, while MRI was used sparingly (3.1%). This demonstrates appropriate resource stewardship, reserving the high-radiation, high-information "pan-scan" for patients meeting specific trauma criteria, as advocated by Moore et al. [9]. Our low MRI utilization rate is consistent with reports from other EUs globally [10, 21], reflecting universal logistical barriers such as longer scan times, patient monitoring challenges, and limited 24/7 availability. The similarity across different healthcare systems suggests these are systemic rather than local issues, pointing to a need for technological or workflow innovations to improve MRI access in emergencies.

4. The diagnostic yield of imaging in our study had a profound impact on patient disposition, directly leading to hospital admission for 46.9% of the cohort and immediate critical care escalation for 5.8%. The relevance of this finding is that it quantifies the role of imaging as a decisive triage tool in the EU. The identification of low-frequency but high-impact pathologies like SAH (2.3%) and aortic dissection (1.6%) validates the use of advanced imaging protocols. These admission and ICU transfer rates are comparable to those reported in studies on high-acuity EU populations [22, 23]. The reason for this strong correlation is straightforward:

the pathologies diagnosed (e.g., hemorrhage, ischemia, severe infection) are, by definition, conditions that require inpatient management or immediate intervention, making imaging the critical determinant of the patient's subsequent care pathway.

5. Finally, this study has several limitations that must be acknowledged. The summary of our findings is based on a single-center, observational design with a modest sample size, which may limit the generalizability of our results to other settings with different patient demographics or clinical protocols. The relevance of this is that our utilization patterns may reflect local practice habits rather than universal standards. These limitations are common in pragmatic EU-based research [24]. A key difference from a larger trial is our inability to formally assess the appropriateness of each imaging request, a complex task requiring expert panel review [25]. This was due to the study's observational design and resource constraints. Future research should aim for multi-center registries to validate these findings and incorporate decision-support tools, potentially powered by artificial intelligence, to help optimize modality selection, reduce unnecessary radiation, and further enhance patient safety in the demanding EU environment [26].

Declarations

Conflict of Interest: The authors declare that they have no competing interests.

Ethical Approval: The study was approved by the Institutional Review Board and conducted in accordance with the Declaration of Helsinki.

Author Contributions: J.D. conceived the study, collected data, and wrote the initial draft. J.S. contributed to the study design, data analysis, and manuscript revision. M.C. supervised the project, provided critical feedback, and approved the final manuscript.

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