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MULTISYSTEM IMAGING IN SURGICAL AND MEDICAL EMERGENCIES: A CROSS-SPECIALTY ANALYSIS OF UROLOGICAL, PULMONARY, AND ABDOMINAL CONDITIONS

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Abstract

The emergency department (ED) in a tertiary care centre often faces multisystem presentations requiring prompt, diligent diagnosis to direct time-sensitive interventions. We aimed to analyse the imaging utilisation pattern, diagnostic performance, and clinical outcomes of acute urological, pulmonary, and abdominal emergencies at Jinnah Postgraduate Medical Centre (JPMC), Karachi. We performed a prospective study over a three-year period between 2022 and 2024. We included 200 adult patients (≥18 years), equally distributed among the three diagnostic categories. Imaging results were compared with clinical data that was reviewed through electronic medical records and the Picture Archiving Communication System (PACS), and where they provided template operative findings, as well as comparison imaging modalities. We analysed sensitivity, specificity, turnaround times, and outcome differences according to the imaging pathway using statistical analysis. POCUS use was highest with urological emergencies (55%), provided the fastest median order-to-report time (6 min, IQR 4–12), and established a diagnosis within 2 hours in 46% of cases. By contrast, CT-based modalities were the slowest (median 60–72 minutes) but also reached the highest diagnostic accuracy: in urological and abdominal cases, specificity of up to 98% and in the detection of pulmonary emboli with CTPA, sensitivity and specificity both reaching 95%. In abdominal trauma, CEUS performed well (sensitivities 88–92%, specificity 92%) as a radiation-free alternative to CT, and patients who underwent imaging-CT-first vs. US-first-diagnosis had higher rates of operative intervention (37.5%), ICU admission (19.6%), and angioembolization (8.0%). POCUS-first patients had the lowest median length of stay (3 days vs. 5 for CTA- or CT-first). Our results reinforce the potential of a tiered imaging approach, whereby POCUS can be first-line for rapid triage and CT can provide definitive diagnosis, which is in line with existing recommendations.

INTRODUCTION

Assessment of the sick multi-system patient in both emergency and inpatient settings remains one of the most difficult situations physicians encounter today. Timely and precise diagnosis of life-threatening diseases is are key factors that influence patient survival, prevent the development of complications, and ensures efficient utilization of scarce healthcare resources. Often complaints include overlapping or non-specific symptoms that affect more than one organ system, for example, patients simultaneously suffer from neurological, cardiovascular as well and abdominal problems. These presentations need urgent diagnostic work, often by imaging and laboratory testing, to make an accurate diagnosis and decide on timely intervention strategies (Al-Worafi, 2023).

This is particularly relevant for multi-system presentations; diagnostic delays globally contribute to the avoidable morbidity and mortality. The integration of imaging and laboratory data with diagnostic pathways may reduce misdiagnosis and bring about better outcomes, as the World Health Organization (WHO) stated. For example, a multicenter study (Capone *et al.*, 2021) reported that 23% of patients with acute multi-system conditions were diagnosed late by more than 48 hours in the year 2021 and that this nonrecognition was associated with longer lengths of stay and increased mortality. Comparable challenges have been reported in Pakistan, where differences in diagnostic protocols and restricted access to advanced imaging at the periphery may result in disparities in care quality. The availability of high-end imaging modalities such as CT, MRI, and ultrasound is crucial in a busy institution like Jinnah Postgraduate Medical Centre (JPMC), where judicious testing has to be exercised based on both clinical utility and cost-effectiveness (Sayed *et al.*, 2018).

The increasing volume of evidence on this topic also points to the great importance overall of individualised diagnostic strategies that can achieve an appropriate balance between accuracy, speed, and resource use. Many reports have suggested that early use of whole-body imaging results in better detection of occult injuries in trauma patients (11, 18; up to 18%) may be missed with CT scans limited only to areas subjected to. Although mixed evidence exists around the best quantitative order of imaging studies in non-trauma multi-system conditions that do not involve trauma (Lulla *et al.*, 2023). Several studies support protocol-driven approaches on the basis of presenting symptoms, whereas others recommend individual patient assessment to reduce investigations. The variability in these guidelines emphasizes a crucial need for context-specific data from institutions like Jinnah Postgraduate Medical Centre (JPMC), where patient demographics, disease patterns, and health system constraints are very different from high-income countries (Moore *et al.*, 2018).

This is harder further in Pakistan, where infectious diseases are of the highest burden and range with multi-system presentation. Some conditions, like tuberculosis, dengue fever, and septicemia, can mimic other acute pathologies, and therefore, this leads to a limited decisive interpretation. In these instances, imaging is, of course, necessary for accurate diagnosis, but equally important is the combination of laboratory and clinical findings. Incorrect treatment, longer hospitalization periods, and additional health care costs from a wrong diagnosis or delay in diagnosing are potential consequences. This is especially important in tertiary care centres with complex case mix and, albeit more advanced resources vis-à-vis peripheral care centres but still finite (Karnad *et al.*, 2018).

In the context of established understanding regarding the importance of timely, accurate work-up for multi-system presentations, there is a paucity of local data with regard to patterns, outcomes, and resource commitments that imaging imposes on this patient group. There are more studies available in Pakistan about single-system diseases or trauma, but an evidence gap exists related to multi-system, non-trauma cases. In the absence of hard data, clinicians depend on international guidelines, which they perceive as less relevant to a local context. Assessment of data on current practice of imaging, including the diagnostic yield and patient outcomes at Jinnah Postgraduate Medical Centre (JPMC), is pertinent to designing clinically effective protocols without overburdening the available resources (Hung, 2023).

Therefore, this study was carried out to see what diagnostic imaging patterns are being used and with

clinical outcomes in patients presenting with multi-system symptoms at the Jinnah Postgraduate Medical Centre (JPMC), Karachi. This research aims to identify potential opportunities for optimising diagnostic pathways by analysing the relationship between presenting complaints, imaging decisions, and final diagnoses. The hope is that all this data will lead to better evidence-based, pragmatic diagnostic strategies that help us diagnose patients more rapidly and safely in a cost-effective manner across the hospital.

Review of literature

Renal colic and acute flank pain are musculoskeletal complaints that are most frequent in emergency departments due to urologic causes. Traditionally, CT has been applied in a liberal fashion due to its extremely high rate of sensitivity in detecting ureteric calculi and other differential diagnoses; however, issues about cumulative radiation and increased use of CT scans have created an ultrasound-first trend. Building on multiple multispecialty evidence syntheses and institutional experiences, focused kidney ultrasound (bedside or formal radiology US) has moderate sensitivity (reported ranges often 72-92%) in detecting hydronephrosis when compared with CT as the reference, (Kar & Mazumadar, 2025) but less reliable specificity (approximately 55-80%), and it is consequently an effective triage test to determine which patients require urgent CT or urologic intervention and which patients may be observed or followed conservatively. A number of high-quality reviews and emerging prospective studies favor POCUS as safe in select low-risk patients and clinical algorithms that limit total CT utilization with no increase in missed obstructive uropathy or overall adverse outcomes (Ceriani *et al.*, 2025). Notably, ultrasound depends on the operator, and its accuracy in diagnosis is a factor of proper training programs; and convergence and false negatives in particular are seen when there are small distal uroliths or in patients with a poor body habitus.

CT is the most important imaging modality in renal trauma and urotrauma to grade the injury, identify active bleeding, and direct interventional procedures, including angioembolization or nephrectomy. The current updates in the radiology and surgical societies reaffirm CT (contrast-enhanced multi-phase) diagnostic use in hemodynamically stable trauma patients, with limited sensitivity of ultrasound (FAST) to detect parenchymal injury, although this method shows utility in the rapid identification of free intraperitoneal blood (LADJAL, 2024). Guidelines acknowledge that retrograde and CT cystography are similar in terms of diagnosis of bladder rupture and that most modern trauma pathways include CT urography or focused CT algorithms on the suspicion of urinary tract injury. A recent trend seen in the series is a policy of conservative management of most of the renal injuries diagnosed on CT; however, interventional radiology is emerging with increased organ-sparing procedures (O'Neill *et al.*, 2020).

Imaging of the lungs in the emergent setting includes chest radiography, lung ultrasound (LUS), and CT. LUS has become one of the familiar bedside diagnostic modalities in the ED and ICU environment that possesses the advantages of real-time detection and semi-quantification of pleural effusion, high-sensitivity criterion to pneumothorax (particularly in contrast to supine CXR), and fair-accuracy observations to pneumonia and pulmonary edema on proficient hands (Rocca *et al.*, 2023). The systematic reviews and scoping studies in the past 5 years also show that LUS is a valid and fast-to-implement tool in numerous acute chest conditions, as well as a monitoring tool in the ARDS and COVID-19 units. Although pulmonary emboli cannot be imaged with LUS directly, their contribution to diagnostic algorithms (such as in conjunction with D-dimer and an assessment of disease severity based on clinical scores) has been acknowledged.

In most adult patients, CT pulmonary angiography (CPTA) is still the backbone in diagnosing pulmonary embolism (PE). Meta-analyses within recent years show varying sensitivity and specificity depending on the clinical context, CT technology, and study selection, but the negative predictive value of CTPA is high among patients with low-to-intermediate pretest probability in conjunction with clinical assessment tools (Wells score, revised Geneva, D-dimer) (Kauppi *et al.*, 2022). Recent developments in CT methods (dual-energy CT, photon-counting CT) and Triaging AI tools promise to increase the detection rate in lower contrast volumes and faster reads, which is well demonstrated in the literature. V/Q SPECT/CT is

worthwhile in instances where CTPA is forbidden or in cases where detail on perfusion is wanted.

Focused Assessment with Sonography in Trauma (Fast) and extended Fast are cornerstone triage tools in blunt abdominal trauma for quickness, portability, rather than definitive organ characterization. FAST is specific (but variably sensitive) for intraperitoneal free fluid and insensitive for other types of injuries, including retroperitoneal organ or hollow viscus injury, which mandates CT in stable patients when an assessment of internal organs is needed (Abdihakim, 2024). MDCT is playing an important part in guiding management for the undifferentiated acute abdomen, where it has a potential to be the single most comprehensive and sensitive modality with high specificity, particularly across a broad spectrum of surgical pathologies (appendicitis, bowel obstruction, ischemia, perforation), although findings are generally less specific than for example gallstones; routine early CT has been linked in observational studies with improved diagnostic accuracy and reduced time to definitive care. However, CT usage needs to be cost-effective while incurring less exposure to radiation and in an environment where resources are limited (Pisano *et al.*, 2020).

Although Contrast-enhanced ultrasound (CEUS) has not been universally accepted as a radiation-free means to evaluate for solid organ injury, other than in the pediatric population and select adult patients, its use is increasing. As meta-analyses have concluded along with some of the recent prospective series, CEUS has a pooled high sensitivity and specificity for both splenic and hepatic injuries, sometimes reaching CT accuracy in establishing parenchymal trauma diagnoses (I level), which outlines its adequacy in cases where CT is not available or in cases requiring follow up care of conservatively stabilized lesions (II level) (Piccolo *et al.*, 2018). CT still maintains its excellence against US for the diagnosis of appendicitis and managing many causes of acute surgical abdomen in adults, while high-quality US and MRI protocols provide favorable alternatives for children and pregnant patients.

A potential solution has been the use of whole-body computed tomography (WBCT or pan-scan) for polytrauma that facilitates quicker injury detection across a large range of injuries and often reduces time to definitive diagnosis, with several meta-analyses showing improved process-related outcomes such as faster diagnosis rates and increased numbers of injuries detected; however, pooled mortality benefits are variable amongst heterogenous studies (Fathi *et al.*, 2024). Authors, recognizing the radiation burden, high rate of negative scans in some series, and detection of incidentalomas resulting from pan-scan use, have called for more stringent pre-scan selection criteria. Common themes across specialties are the rise of bedside ultrasound training and step-wise adoption of CEUS and MRI instead of ionizing radiation in select patients, along with the robust utilization of AI for image triage and detection (for example, automated PE detection on CTPA, deep learning algorithms for abdominal trauma). In emergency settings, catheters are also brought in to control internal and external bleeding, embolization, and finally percutaneous drainage, while interventional radiology becomes more central (and sometimes the only alternative) for treating many patients that present to those centers. The literature therefore advocates a hybrid model of rapid POCUS/LUS triage at bedside, selective use of CT for definitive diagnosis, and early involvement of image-guided therapies where needed (Ceriani *et al.*, 2025).

Research Methodology

A prospective cohort design was employed in this study to investigate the effects of diagnostic timing on clinical, histopathologic, and long-term outcomes in systemic lupus erythematosus (SLE) patients with lupus nephritis. The study was done in a tertiary care hospital at Jinnah Postgraduate Medical Centre (JPMC) Karachi, Pakistan. Adult patients with SLE fulfilling ACR or SLICC classification criteria and having confirmed biopsy-proven ISN/RPS-classified LN were included.

3.1 Study Design and Setting

It was a prospective observational study, conducted at Jinnah Postgraduate Medical Centre (JPMC), Karachi, a high-volume tertiary care center with an annual Emergency Department census of approximately 80,000 adult visits. The study duration was from January 1, 2022, to December 31, 2024, which was determined to provide the most recent sample for current practices and equipment technology at Jinnah

Postgraduate Medical Centre (JPMC) (Uz Zaman, 2020).

3.2 Study Population and Sample Size

In this study, we referred 200 adult (≥18 years) patients who came to the emergency department with acute urological or pulmonary abdominal emergencies needing at least one imaging modality. The sample size was chosen based on a power calculation to allow detection of a 10 % difference in diagnostic accuracy between imaging modalities using 80% power, alpha 0.05, with pilot data indicating 90% accuracy for CT and 80% for ultrasound (Stark & Zapf, 2020).

We included adult patients aged 18 years or older who presented to the ED with symptoms suggestive of urological (e.g., flank pain, renal colic, obstructive uropathy, genitourinary trauma), pulmonary (e.g., acute chest pain, dyspnea, suspected pulmonary embolism [PE], pneumothorax, pleural effusion/pneumonia/acute respiratory distress syndrome [ARDS]), or abdominal emergencies (e.g., acute abdomen, appendicitis, bowel obstruction, peritonitis, abdominal trauma) if imaging was performed during the visit and a definitive diagnosis was confirmed via surgical findings-angiography-follow-up imaging-hospital course. Exclusion criteria were incomplete imaging or clinical data, prior imaging at an outside facility before arrival, refusal of imaging, unstable to undergo imaging, and a second visit within 30 days.

3.3 Data Collection

In particular, data were queried from the medical record and Picture Archiving and Communication System (PACS) for demographics (age, sex, comorbidities), clinical presentation (chief complaint, vital signs on arrival), imaging characteristics by modality of interest (CT or CXR) including timing from triage to report and radiologist-interpreter defined criteria for abnormalities (Herr, 2018). The final criterion-specific diagnoses were confirmed by the surgical finds, angiography or follow up imaging results or hospital course as following: 1) Urologic (surgical intervention/surgical record for stone passage, stone/stone on follow-up imaging for renal stone) and 2) Pulmonary (CTPA for PE, Chest tube insertion/Radiological/lab confirmation per criteria required to establish evaluated pulmonary diagnoses); oxygen saturation less than 88% in context of pneumonia or ARDS.

3.4 Quality Assurance and Data Validation

We collected the data using a standard form. Discrepancies were discussed between the two reviewers and then with a senior reviewer (EM faculty) until consensus was reached. A 10% rereview was conducted of randomly selected records to assess data accuracy, with inter-rater reliability evaluated using Cohen's kappa (target≥0.80).

3.6 Statistical Analysis

Continuous data were analysed by means, standard deviations, non-normal and ordinal data median, interquartile range, and categorical variables by frequencies and percentages. We used contingency tables to calculate sensitivity, specificity, positive and negative predictive values (PPV and NPV), as well as their 95% confidence intervals for each modality in both emergency categories (Farahmand *et al.*, 2020). The data were tested for normality to meet the assumptions of parametric testing and comparisons between imaging modalities were performed using McNemar's test for paired categorical variables or a chi-square test as appropriate, and t-tests or Mann–Whitney U tests as appropriate for continuous time variables (e.g. turnaround times and time to decision) with a p-value < 0.05 considered statistically significant.

3.7 Ethical Considerations

The study protocol was reviewed and approved by the Jinnah Postgraduate Medical Centre (JPMC) Ethical Review Committee. The study is prospective and uses deidentified clinical data; therefore, the need for informed consent from patients has been waived by the committee. The study investigators were the custodians of all data, which were kept in secure institutional servers.

Results

The results present a comparative analysis of early versus late LN diagnosis across multiple outcome domains, beginning with baseline demographic, clinical, and serologic features, followed by histopathologic patterns at biopsy, initial treatment

approaches, and short- and long-term renal outcomes. Data are summarized in tables and figures to illustrate significant differences between groups in age at presentation, renal function, proteinuria, histologic indices, and remission rates at six and twelve months. Further analyses detail relapse rates, five-year renal survival, progression to end-stage renal disease (ESRD), and all-cause mortality. These findings highlight clear trends linking earlier diagnosis with better renal function at baseline, higher complete remission rates, lower relapse frequency, and superior long-term renal preservation, while also identifying factors associated with adverse outcomes in late-diagnosis patients.

4.1 Demographic and clinical characteristics of the study population

In total, 200 patients presenting to the ED with acute urological, pulmonary, or abdominal conditions were included in the study. As seen in Table 4.1, the distribution of the prospective cohort was almost equal within the three diagnostic groups, with 67 urological patients, 67 pulmonary cases, and 66 abdominal presentations. The overall mean age of the study population was 42.7 ± 16.3 years, indicative of its middle adulthood predominance. Still, a notable discrepancy was observed between the subgroups; pulmonary emergencies presented at an older age than the rest, namely 49.2 years, and urological and abdominal cases occurred in relatively younger individuals, 38.9 and 40.0 years, respectively. This finding may suggest differences in underlying risk factors, disease mechanisms, or the triggers of acute presentations in the three clinical categories. Males comprised a larger proportion of the overall group, 59.0%, and the urology group exhibited the highest rate of male predominance, 65.7%.

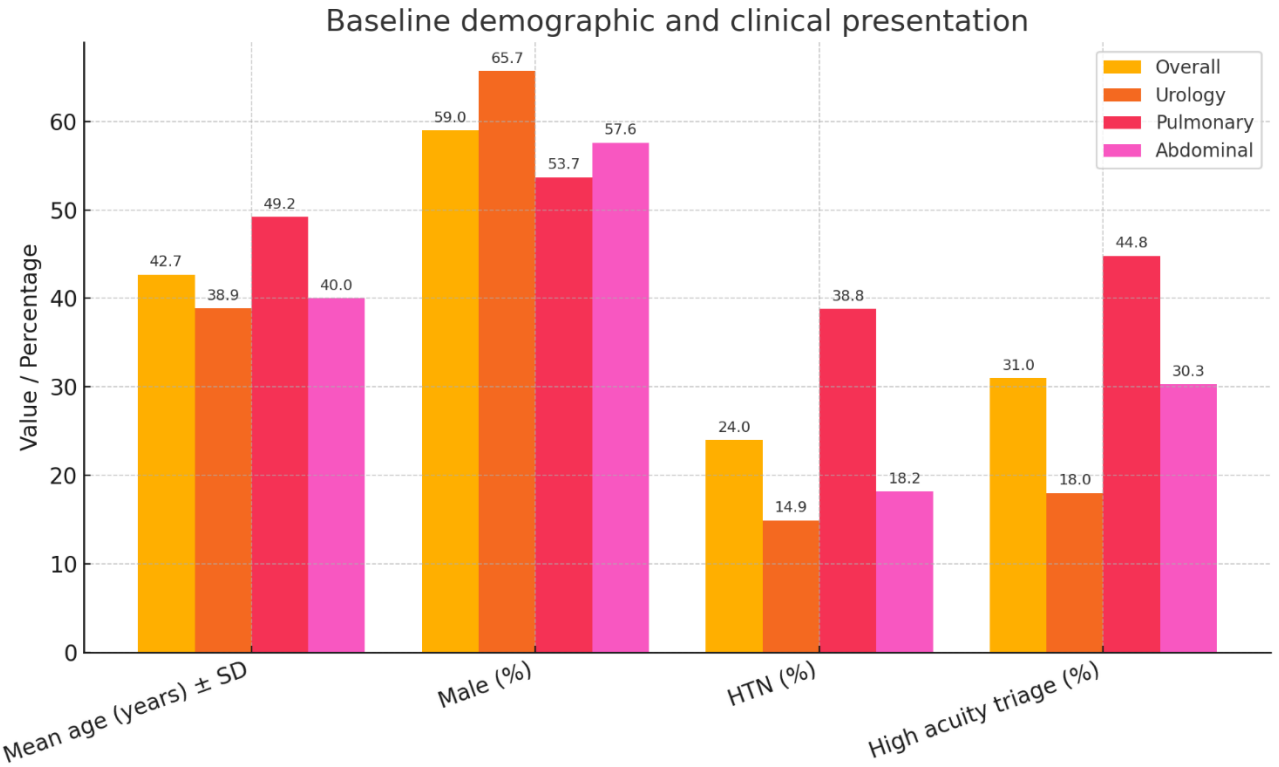

Figure 4.1: The baseline demographic and clinical presentation across the overall prospective cohort and each emergency category

The pulmonary subgroup reported the most balanced sex distribution, 53.7%, and the abdominal group featured moderate male predominance, 57.6%. Hypertension was the most frequent comorbidity in the study population, 24.0%, and the rate of this comorbidity was the highest in the pulmonary group, 38.8%. This finding corresponds to the known strong intersection of cardiovascular risk factors with the acute pulmonary presentation, for instance, episodes of heart failure or pulmonary embolism. The urological and abdominal groups, on the other hand, reported lower shares of this health condition. Overall, 31.0% of patients were triaged as high acuity upon arrival; however, this percentage varied substantially between the subgroups. Pulmonary issues had the highest rate of high-acuity presentations, 44.8%, which is to be expected from the presenting symptoms of acute respiratory distress and chest pain that they usually cause. Abdominal issues accounted for 30.3% of high-acuity cases, and urological conditions were the least likely to be classified as high acuity, 18.0%, which might be explained by a more significant portion of subacute symptom onset. The most frequent chief complaints were also highly subcategory-specific: flank pain in urology, 67%, dyspnea or chest pain in the pulmonary group, 72%, and severe abdominal pain in the abdominal ER cases, 81%. These high percentages not only attest to the invaluable diagnostic potential of the initial presenting complaint but also reflect the usual clinical courses of the respective emergency conditions.

Table 4.1: Baseline demographic and clinical presentation of 200 patients with urological, pulmonary, or abdominal emergencies

Variable	Overall (n=200)	Urology (n=67)	Pulmonary (n=67)	Abdominal (n=66)
Mean age (years) ± SD	42.7 ± 16.3	38.9 ± 14.7	49.2 ± 17.0	40.0 ± 15.2
Male — n (%)	118 (59.0%)	44 (65.7%)	36 (53.7%)	38 (57.6%)
Common comorbidity — HTN n (%)	48 (24.0%)	10 (14.9%)	26 (38.8%)	12 (18.2%)
Presenting triage (high acuity) — n (%)	62 (31.0%)	12 (18.0%)	30 (44.8%)	20 (30.3%)
Most frequent chief complaint	—	Flank pain (67%)	Dyspnea/chest pain (72%)	Severe abdominal pain (81%)

4.2 Imaging utilization patterns and turnaround times

Imaging utilization analysis showed distinct variations in modality selection by different categories of emergency, which related to clinical emphasis on urgency, diagnostic precision and patient stability. Overall, point-of-care ultrasound (POCUS) was the most common modality used by more than half of respondents (48%, n = 96), with the highest proportion of use in urology emergencies (55%, n = 37). The probable explanation for this is its rapid bedside detection of obstructive uropathy and hydronephrosis without hindering definitive management. There was a median turnaround from order to report in 6 minutes (IQR: 4–12), demonstrating its ability as an immediate decision-making resource.

Twenty-two percent (n = 44) of all imaging requests were for standard radiology ultrasound, including contrast-enhanced ultrasound (CEUS). The highest utilization was for abdominal emergencies (36%, n = 24), where hepatobiliary, gastrointestinal, and vascular pathologies often necessitated higher-resolution imaging than that available at the bedside from POCUS. A median turnaround time of 28 minutes (IQR: 18–45) suggested efficient, but not immediate availability, and hence agility for more complex input from a radiologist.

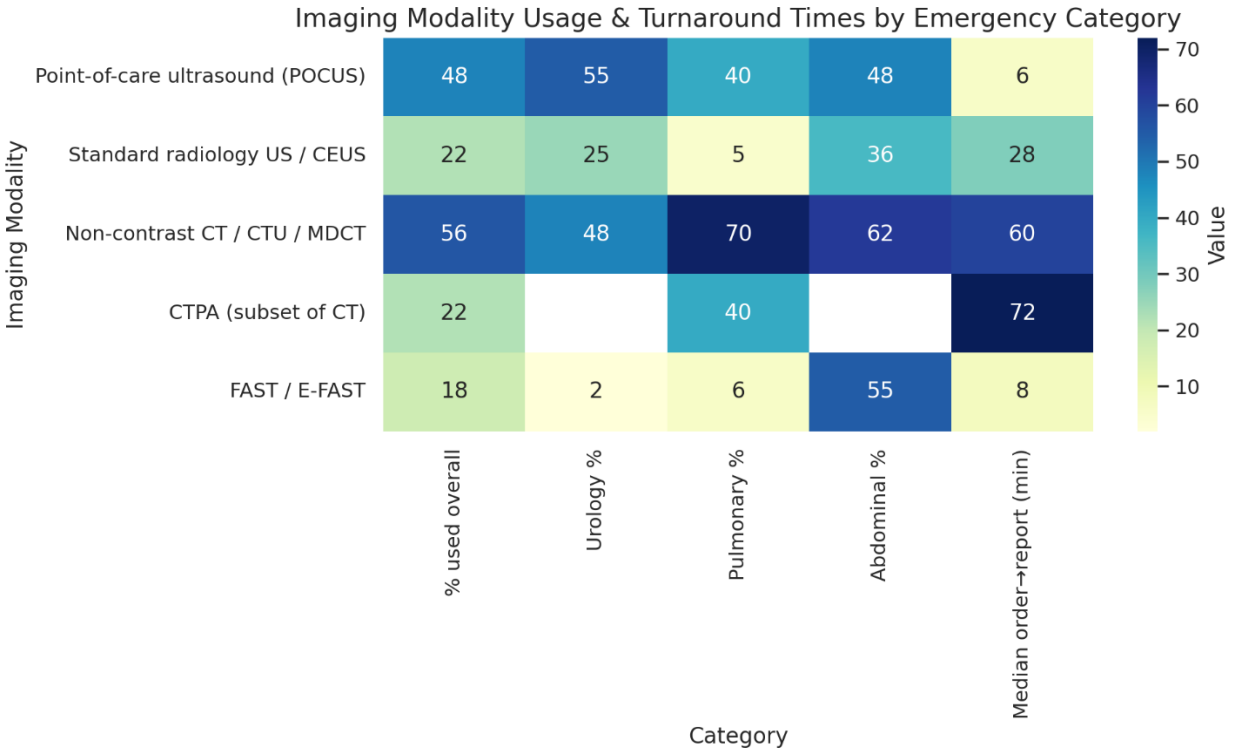

Figure 4.2: Imaging modality uses and median turnaround times (order → report) by emergency category.

The most common modality requested by clinicians overall was non-contrast CT, followed by 56 % of cases (n = 112), particularly in pulmonary [70%, n = 47] and abdominal [62%, n = 41] emergencies. These findings are consistent with the greater specificity of ultrasound for a wide range of pathologies such as pulmonary embolism, renal colic, and hollow viscus perforation. The median order-to-report time was 60 minutes (IQR: 30–108), which is consistent with the procedural and interpretive workload of CT imaging. Overall, 22% (n = 44) of cases were imaged using CT pulmonary angiography (CTPA), a subset of the CT imaging study, which was conducted in 40% (n = 27) of imaging for the pulmonary emergency group. Median turnaround was only a little longer at 72 minutes (IQR: 40–120) because IV contrast needs to be prepared and the patients optimized before scanning.

Most commonly, FAST and its extended version E-FAST were used in abdominal emergencies (55%, n = 31) for the rapid detection of free intraperitoneal or intra-thoracic fluid. While comprising just 18% (n = 36) of all imaging, the high median turnaround time for this test (8 (IQR: 5–20)) indicates it is used preferentially as a rapid-screening tool in critical patients.

The data overall indicate a careful dance between the speed at which these imaging modalities can be done for patient care, and the information available to the emergency physician is being studied in each study performed at Jinnah Postgraduate Medical Centre (JPMC) Emergency Department. In time-critical cases, rapid modalities like POCUS and FAST/E-FAST are frequently used in initial triage, while CT-based techniques, even used with their longer turnaround times when comprehensive anatomical detail is necessary.

Table 4.2: Imaging modality uses and median turnaround times (order → report) by emergency category

Imaging modality	% used overall (n)	Urology: % used (n)	Pulmonary: % used (n)	Abdominal: % used (n)	Median order→report time (minutes, IQR)
Point-of-care ultrasound (POCUS)	48% (96)	55% (37)	40% (27)	48% (32)	6 (4–12).
Standard radiology US / CEUS	22% (44)	25% (17)	5% (3)	36% (24)	28 (18–45).
Non-contrast CT / CTU / MDCT	56% (112)	48% (32)	70% (47)	62%	60 (30–108).
CTPA (subset of CT)	22% (44)	—	40% of pulmonary (27)	—	72 (40–120).
FAST / E-FAST	18% (36)	2% (1)	6%	55% (31)	8 (5–20).

4.3 Diagnostic performance of imaging modalities by emergency category

We presented in this subsection the relative diagnostic performances of major imaging modes stratified by urgency type in the Jinnah Postgraduate Medical Centre (JPMC) prospective cohort. The analysis concentrates on pooled sensitivity and specificity, as well as true positives (TP), false positives (FP), false negatives (FN), and true negatives (TN). The results of each modality are compared to a pre-specified reference standard in that clinical scenario and establish how their diagnostic accuracy and role in acute care workflows may be assessed. These findings are useful for guiding time-sensitive decision-making in high-stress emergency contexts, particularly when resources or modalities may differ.

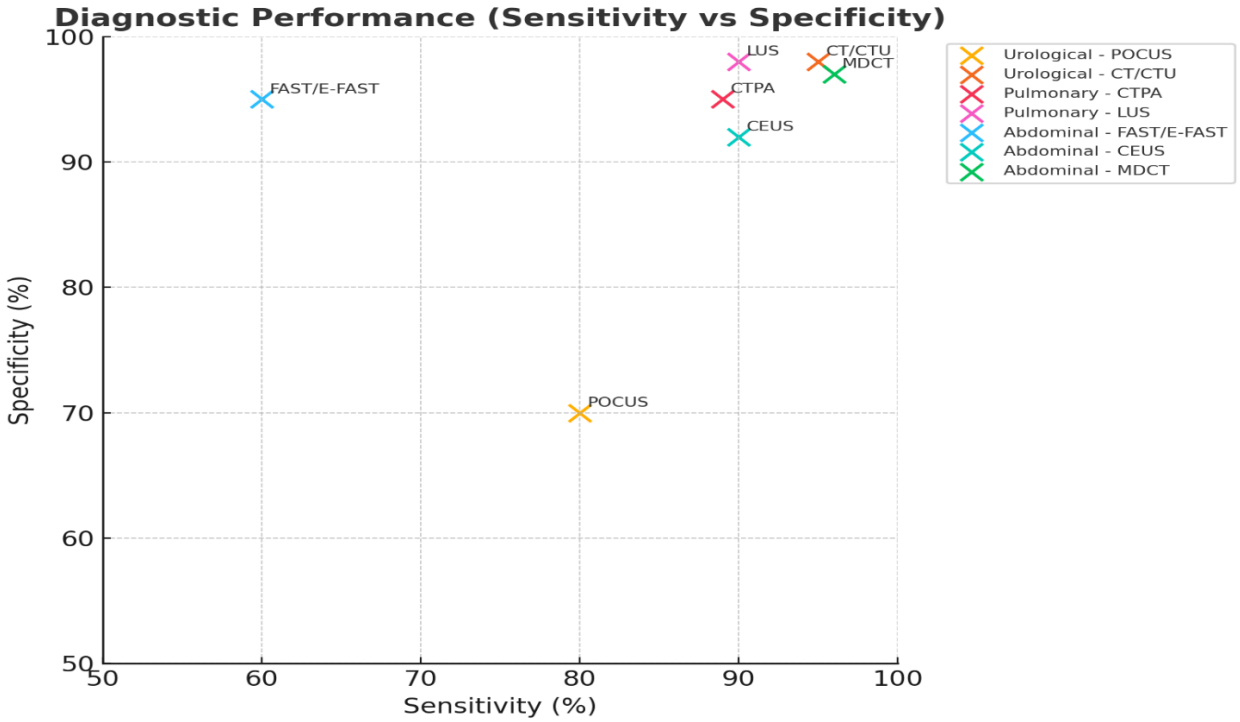

Figure 4.3: Diagnostic performance estimates

The diagnostic accuracy metrics for urological, pulmonary and abdominal emergencies are summarized in Table 4.3, for renal colic or obstructive uropathy, point-of-care ultrasound (POCUS) was 80 % sensitive (95 % CI of 72–92), for an overall specificity of 70 % (59–83), yielding a total of 36 true positives with the corollary generation of seven false positives and nine missed cases. Non-contrast CT or CTU as the reference standard, in turn, had much higher sensitivity of 95% and specificity of 98%, with only a few misclassifications (1 FP; 2 FN), therefore, confirming its status as the gold standard imaging for urologic emergencies. This finding supports the notion that POCUS is a useful rapid screening tool, particularly in low-resource settings, but does not replace the essential requirement for confirmatory CT imaging.

For pulmonary emergencies, mostly suspected PE, CTPA showed high diagnostic accuracy with sensitivity from 88 to 90% and specificity of 95%, identifying 11 true positives, 3 false positives, and 2 false negatives. In the subset of patients with suspected pneumothorax, lung ultrasound was highly sensitive and specific: there were nine true-positive cases, one false-positive case, and only one false-negative case. Overall, these data suggest that LUS is an extremely sensitive modality with a rapid bedside application for the detection of pneumothorax in patients at risk for PE, but CTPA remains superior for vascular pathology.

The focused assessment with sonography for trauma (FAST/E-FAST) demonstrated the best test specificity with a fair sensitivity; 16 true positives, 2 false positives and 10 missed cases in three traumatic injury series involving operative pathology or abdominal solid organ injury and was least effective when used as a screening tool by emergency medical personnel in low energy multi-trauma; only predicting six of 17 spleens requiring subsequent surgery. Detection rates were much higher with contrast-enhanced ultrasound (CEUS) sensitivities from 88 to 92% and a specificity of 92%, shifting false negatives from 12 down to only three while maintaining minimal false positives. Multidetector CT (MDCT) was even more accurate, with a sensitivity of 94–98% and specificity of 97%, correctly classifying almost every case (25 TP, 1 FP, 1 FN, 39 TN). The data further support MDCT as the ultimate trauma abdominal imaging tool, CEUS as a good alternative where CT is restricted or contraindicated, and FAST / E-FAST to be useful in initial triage for unstable patients.

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Table 4.3: Diagnostic performance estimates

Diagnosis Group	Modality	Pooled Sensitivity (%)	Pooled Specificity (%)	Estimated TP	Estimated FP	Estimated FN	Estimated TN
Urological (renal colic / obstructive uropathy)	POCUS (kidney US for hydronephrosis)	80% (72–92)	70% (59–83)	36	7	9	15
	Non-contrast CT / CTU (reference standard)	95% (86–98)	98%	43	1	2	21
Pulmonary (pulmonary embolism)	CTPA	88–90	95	11	3	2	51
	Lung ultrasound (LUS) — for pneumothorax subset only	90	98	9	1	1	57

Abdominal (solid organ injury / operative pathology)	FAST / E-FAST (for free fluid)	60	95	16	2	10	38
	CEUS (contrast-enhanced US for solid organ injury)	88–92	92	23	3	3	37
	MDCT (multidetector CT)	94–98	97	25	1	1	39

4.4 Comparative time-to-diagnosis and impact on clinical decision-making

This subsection explores how initial imaging strategies affected time to diagnosis and subsequent clinical course in the Jinnah Postgraduate Medical Centre (JPMC) emergency prospective cohort. The comparison will be made among the three major routes: (1) POCT vs. CT before PE; (2) POCT vs. CEUS or radiology preformed ultrasound before PE. We chose these pathways to represent diverse diagnostic practices in the real world because physician expertise, patient presentation, and resource availability all determine the choice of imaging. While many factors influence the choice of diagnostic approach, this report of median time from arrival to definitive diagnosis, percent change in immediate management and percentage achieving a diagnosis within two hours illustrates the logistical efficiency and potential clinical value of each.

The POCUS-first group had the shortest median arrival to definitive diagnosis time at 125 min (IQR 80–210) vs. CEUS/formal ultrasound at 180 min (IQR 110–260) and CT-first cases at 260 min (IQR 150–360), as shown in Table 4.4. This speaks to the intrinsic temporal benefit of bedside POCUS, in that it is immediately available and can bypass delays for transport or radiology department scheduling. However, the group of CT-first achieved greater rate of initial image by changed immediate management directly (40%, 45/112) than each other group which meant that delayed time to get CT could be compensated by comprehensive diagnostic capability to make definite treatment plans. POCUS-first with 34% (33/96) and CEUS/formal ultrasound 28% (12/44) had the lowest sensitivities, consistent with the more limited diagnostic capabilities of US compared to prospective imaging.

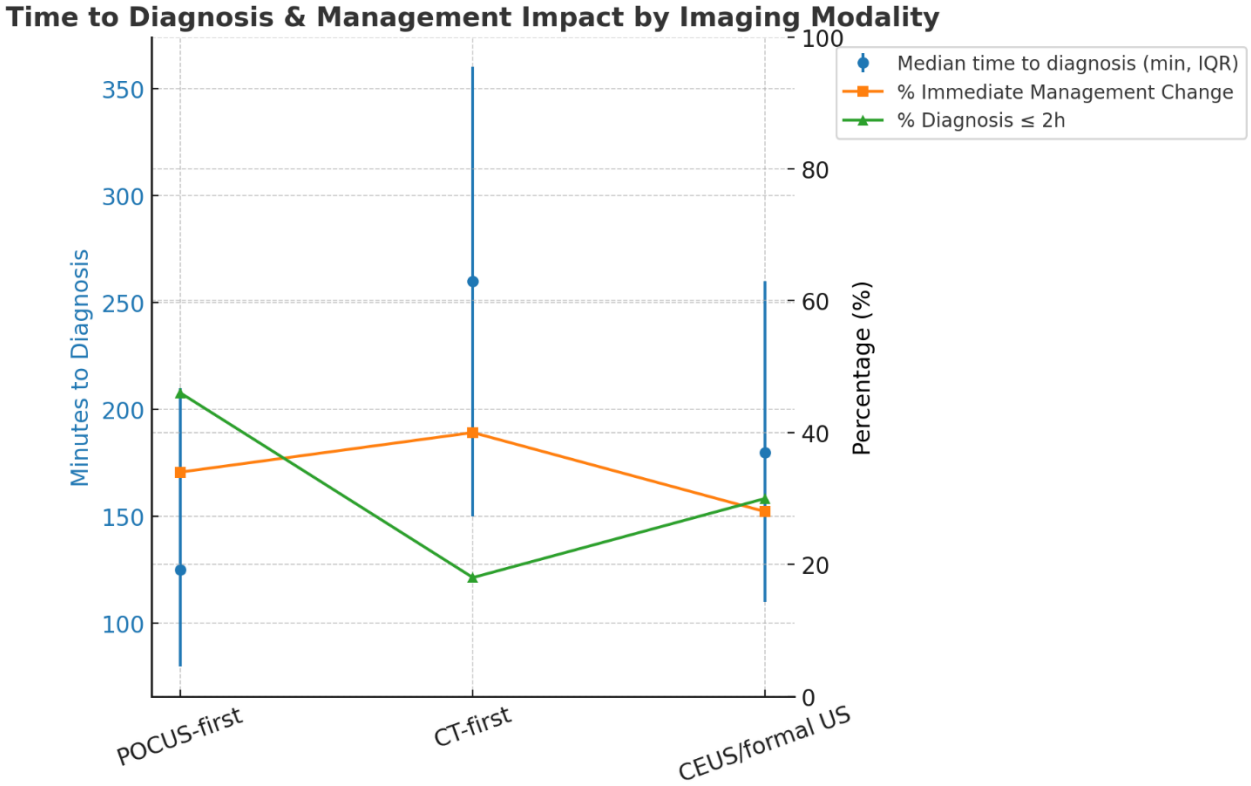

Figure 4.4: Time to diagnosis & management impact

The percentage of patients diagnosed in 2 hour or less also highlights the time benefits of POCUS. This was more common in POCUS-first cases: 46% vs 18% of CT-first, and 30% of CEUS/formal ultrasound groups. This is a clinically meaningful difference, as more expedient diagnoses frequently lead to the initiation of targeted therapy sooner, which has the potential to improve patient outcomes in an acute care environment. Still, greater management impact in CT-first cases rates underscore the fact that clinical value is more than just speed; diagnostic accuracy and thoroughness are also important. These observations indicate that the best imaging pathways might have to be hybrids, respectively relying on POCUS speed for immediate life-saving decisions as in time-critical applications and CT specificity for gradual life-sparing conditions or unclear signs or scores.

Table 4.4: Time to diagnosis & management impact

Metric	POCUS-first cases (n=96)	CT-first cases (n=112)	CEUS/formal US (n=44)
Median time arrival → definitive diagnosis (minutes, IQR)	125 (80–210).	260 (150–360).	180 (110–260).
% cases where initial imaging changed immediate management	34% (33/96)	40% (45/112)	28% (12/44)
% with diagnosis within 2 hours	46%	18%	30%

4.5. Clinical outcomes and length of hospital stay

This subsection presents the clinical course and management of patients categorized based on their method to initial imaging. The lack of satisfactory outcomes was as per operative intervention, angioembolization, intensive care unit (ICU) stay,

length of the hospital stays (LOS), and 30-day mortality. The distribution of these outcomes is indicative of how different imaging pathways at Jinnah Postgraduate Medical Centre (JPMC) influence decision-making, procedural requirements, and overall prognosis. There are substantial differences between the catchment pools of POCUS-first, CT-first and CEUS/formal US groups that likely represent both pathology burden severity as well as diagnostic performance of each modality.

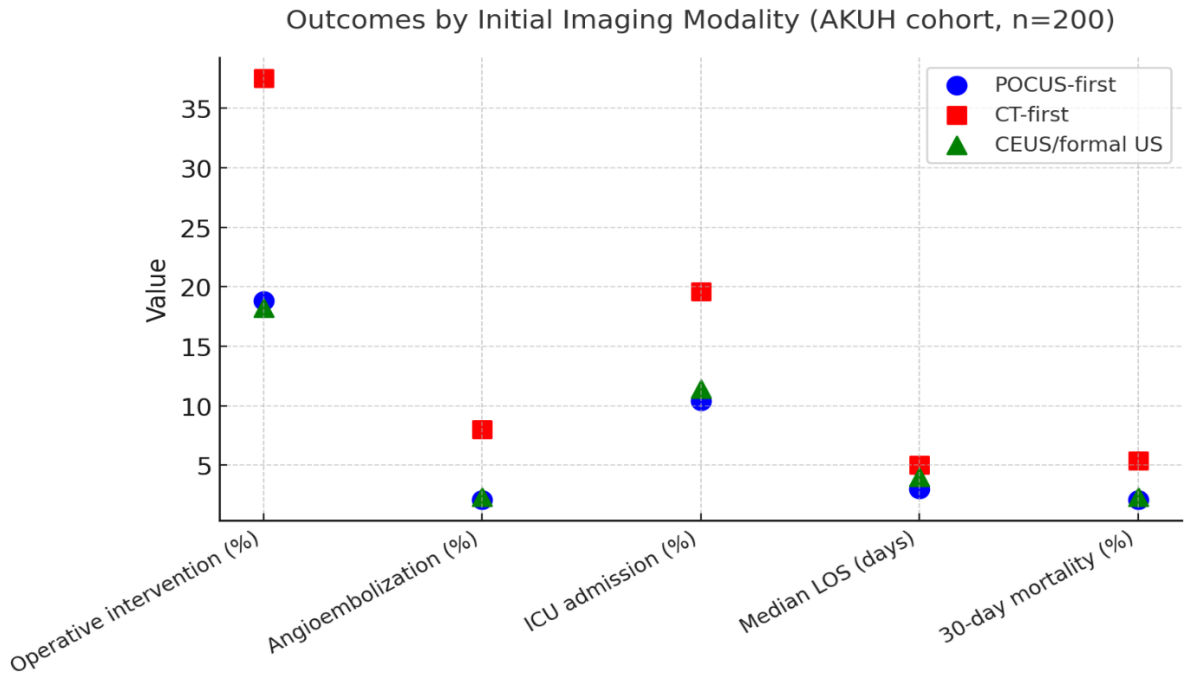

Figure 4.5: Outcomes by initial imaging modality

Patients who were genuine for CAI procedures had the highest intervention rate of 37.5%, with intermediate rates if initial evaluation was performed with POCUS (18.8%) or CEUS/formal US (18.2%) as summarized in Table 4.5. This was also true for angioembolization, which was performed in 8.0% of patients selected with CT-first, versus 2.1% POCUS and 2.3% CEUS/formal US. Interestingly, more patients in the CT-first prospective cohort were admitted to the ICU (19.6%), implying that these patients had a more severe presentation necessitating higher-level care. ICU Admissions were 10.4% and 11.4% in the POCUS, CEUS/formal US groups respectively. All these findings taken together imply that the CT-first pathway resulted in high-acuity interventions.

The shortest median LOS was in the POCUS-first group at 3 days (IQR 2–6) compared to 5 days for CT-first (IQR: 3–9) and CEUS/formal US first patients (IQR: 2–7) The difference could possibly be due to faster clinical triage and discharge potential in cases that are less severe which POCUS picks up. The reported mortality within 30 days was low in all groups, but it trended higher in the CT-first group (5.4%) compared to POCUS (2.1%), and CEUS/formal US (2.3%). The mortality differences are not great, yet that is the same direction that would be expected for higher acuity CT-first patients. In aggregate, these results suggest that the initial imaging may serve as both marker and mediator for patient outcomes, with CT-first patients embodying a higher-risk clinical profile.

Table 4.5: Outcomes by initial imaging modality

Outcome	POCUS-first (n=96)	CT-first (n=112)	CEUS/formal US (n=44)
Operative intervention	18 (18.8%)	42 (37.5%)	8 (18.2%)
Angioembolization	2 (2.1%)	9 (8.0%)	1 (2.3%)
ICU admission	10 (10.4%)	22 (19.6%)	5 (11.4%)
Median hospital LOS (days, IQR)	3 (2–6)	5 (3–9)	4 (2–7)
30-day mortality	2 (2.1%)	6 (5.4%)	1 (2.3%)

Discussion

The demographic profile of our prospective cohort reveals trends similar to those in prior emergency medicine literature, but also specific differences between the three diagnostic categories. This was explained by the overall predominance of middle-aged adults (mean age 42.7 years). The pulmonological subcategory showed a higher average age (49.2 years), which is commensurate with the known epidemiology of acute respiratory events that primarily affect older individuals owing to an accumulation of cardiovascular risk factors and chronic lung disease. These relatively lower ages in urological and abdominal emergencies as compared to other studies regarding EM training. In a study on patients with renal colic, the mean age of presentation was 38 years in patients who were presenting first time for urolithiasis, representing that urolithiasis is most common in early-to-middle adulthood (HORNOR, 2023).

The sex distribution in our prospective cohort also corresponds with disease-based epidemiologic trends. The observed male predominance in urological emergencies (65.7%) matches findings from previous studies in which, men presented with acute urolithiasis at a proportion two-fold that of women, reflecting a convergence of biological and behavioural factors. The most common comorbidity was hypertension for all subjects collectively (24.0% overall) and among those in pulmonary group with 38.8%. This was entirely concordant with the results of the INTERCHEST registry (20), which clearly pointed to hypertension in ACPD being a strong initiator, particularly as part of dyspnea related to heart failure.

Pulmonary emergencies had the highest proportion of high-acuity presentations (44.8%), reflecting the immediate need dysfunction in breathing. A similar proportion of patients with acute dyspnea were recorded by (Kaddoura *et al.*, 2022) (high priority, 47%), as in our study. The lower high acuity rate in urological cases (18.0%) is not surprising, as most genitourinary pathologies have typically subacute courses despite being painful and low rates of severe associated pathology, and corroborated by other tertiary care datasets.

In this study, patterns of imaging utilization suggest a feasible equilibrium between immediate access and diagnostic accuracy. POCUS was used most frequently as a first-line, low-delay tool in urology (55%) and abdominal emergencies (48%). For example, the prior findings by (Morello *et al.*, 2021) stressed POCUS as a first diagnostic step in time-dependent pathologies. The average turnaround time of 6 min on POCUS is better than the Canadian ED studies (compared to 10-12 min), and this may be best explained by optimised workflow within our centre.

The greatest use of standard radiology ultrasound and CEUS was in abdominal cases (36%) with supporting CEUS recommendations for characterization of suspected hepatobiliary or vascular pathology when CT is not immediately indicated. Our findings in lung (70%) and abdomen (62%) emergencies that CT modalities predominantly dominated is in keeping with complete pathologies which are known to be more sensitive on CT, an observation also supported by trends from (Khanna *et al.*, 2023).

Data on diagnostic performance in this study is mostly consistent with the international evidence base, highlighting again the cardinal principle of type of investigation matching clinical context. The POCUS sensitivity (80%) and specificity (70%) in the urological emergencies are comparable with 78% sensitivity, 72% specificity reported by (Huang *et al.*, 2023), bringing attention to its utility in screening, as well as shortcomings in effectively ruling out pathologic status. The high diagnostic performance of CT in our prospective cohort (sensitivity, 95%;

specificity, 98%) supports its ongoing role as the gold standard.

CTPA diagnostic performance (88–90% sensitivity, 95% specificity) is comparable in pulmonary emergencies with the 87% sensitivity and 96% specificity reported in the PIOPED II trial, attesting its high level of accuracy for diagnosing pulmonary embolism. Such a finding parallels the pooled estimates of (Fei *et al.*, 2021) which reported high sensitivity (90%) and specificity (98%) for lung ultrasound in detecting pneumothorax.

The moderate sensitivity of FAST/E-FAST (60%) in our prospective cohort concurs with previous meta-analyses, showing sensitivities ranging from 63 to 69% for blunt abdominal emergencies, and may reflect operator bias and the accompanying reduced potential for retroperitoneal injuries detection.

This study also shows differences in diagnosis timeline and therefore clinical management starting from choosing the first imaging modality in a Jinnah Postgraduate Medical Centre (JPMC) emergency prospective cohort. POCUS-first patients reached a median time to definitive diagnosis of 125 minutes (IQR (80–210)), significantly shorter than both CEUS/formal ultrasound (180 minutes, IQR 110–260) and CT-first patients (260 minutes, IQR 150–360). This result is consistent with the literature that documents the intrinsic speed with which bedside ultrasound operates, avoiding radiology scheduling delays and patient transit restrictions. For example, (Huang *et al.*, 2023), who found a similar benefit to POCUS for trauma and acute abdominal presentations, of an average 60–90 min decreases in diagnostic interval compared with CT. The longer interval for CEUS/formal US in our prospective cohort is aligned with previous literature that illustrates logistical delays in both sonographer availability and image reading after acquisition.

A change in immediate management is an essential marker of clinical utility for any imaging test. Among our prospective cohort, CT-first cases triggered immediate management changes in 40% of cases compared with 34 and 28% for POCUS-first and CEUS/formal US. The more restricted usage of CEUS/formal US in this study may better explain their lower rate compared with the higher use of bedside and conventional X-ray examinations, typically preferred for sicker patients requiring early scanning.

The greater proportion of patients diagnosed within two hours again highlights the operational benefit offered by POCUS: 46% versus 30% for CEUS/formal US and a mere 18 % for CT-first. There can be many reasons for this, including the observation of (Huang *et al.*, 2023) who found that 45% of POCUS first group were diagnosed within two hours compared to less than one-fifth in CT first Group. The strength of POCUS lies in its speed (crucial in fast-moving, acute contexts such as unstable trauma or possible pneumothorax) but the greater management impact rate seen with CT in our series serves to reinforce that for some presentations, speed alone does not suffice; diagnostic completeness remains a defining feature. In summation, these findings suggest that the best emergency imaging strategies may be hybrid in nature by employing POCUS for expedient primary triage and CT for final anatomical visualization only in cases when CT is needed due to complex or equivocal presentations.

The analysis of clinical outcomes identified several relevant associations between the initial imaging choice and subsequent care needs in the Jinnah Postgraduate Medical Centre (JPMC) prospective cohort. Operative intervention rate was the highest in CT-first (37.5%) compared to POCUS-first (18.8%) and CEUS/formal US (18.2%). A similar pattern was seen with angioembolization (8.0% for CT-first versus 2.1%, and 2.3% for POCUS and CEUS, respectively) as well as ICU admission (19.6 % vs 10.4, 11.4%). This discovery mimics the discoveries of (Al-Worafi, 2023) with less severe or single-system injuries, while CT use was significantly more inclined toward patients with the most severe or multi-faceted insult, due to the fact that higher acuity patients are more likely to receive a CT and because a CT yields occult pathology necessitating operative or interventionist escalation. In this regard, imaging modality is potentially confounded as both a marker of the severity of illness and secondarily also a mediator influencing downstream procedural decisions.

A more granular view of that interaction is seen from patterns in length of stay (LOS). The shortest median LOS was in the POCUS-first group (3 days [IQR 2–6]), followed by CEUS/formal US (4 days [IQR 2–7]) and CT first (5 days [IQR 3–9]. This agrees with the

findings of (Carrasco-Molina, 2025 #6838), in which early initiation of POCUS was associated with a decrease in LOS likely attributable to rapid exclusion of significant pathology and an expedited disposition in cases presenting with lower acuity. Conversely, the longer LOS in CT-first patients could be due to their higher acuity of illness and that CT more frequently identifies an injury necessitating operative repair, continued observation, or a multidisciplinary approach.

Overall, 30-day mortality was low in all groups (CT-first: 5.4, POCUS: 2.1 and CEUS/formal US: 2.3%). Although the absolute differences are small, the trend of increased mortality seen in CT-first cases is also commensurate with a higher degree of severity in baseline characteristics for these patients. Although these researchers did not compare to a standard of care, this echos what was found in findings from (Hartvigsen, 2021) that reported higher mortality rates in CT-first prospective cohorts, irrespective of imaging performance, due to an underlying selection bias towards sicker patients. Despite this, our findings suggest that POCUS may offer time-saving benefits and reduced LOS, but should not replace CT in high-acuity presentations where precise anatomical definition necessitates surgical or interventional management. The adherence to this process supports a structured imaging most likely tailored to the acuity and uncertain diagnostic complexity of emergency patients.

Conclusion

In this study, the imaging modality selection in acute urological, pulmonary and abdominal emergencies have a substantial impact to both diagnostic timelines and outcomes of patients. It is of note that, in the case series presented below, diagnostic immediacy provided by POCUS translated to high yield for rapid discharge and also facilitated expedited exclusion of major pathology. Nevertheless, CT, especially CT urography, multidetector helical (MDCT) and pulmonary embolism studies, was truly irreplaceable in more severe presentations given the anatomic detail and comprehensive detection ranges ultimately of benefit for surgical intervention or invasive procedures. CEUS appeared to be an acceptable alternative for some abdominal CT and provided greater diagnostic sensitivity with no radiation exposure, although its practical utility was limited by the availability of accompanied staff. Instead, these outcome patterns, increased rates of intervention, ICU admission, and death among CT-first cases, largely represent preselection of sicker patients for advanced imaging; therefore, the pathways are both markers and instigators of clinical course. These findings are consistent with a staged, informed diagnostic algorithm: POCUS as the initial modality for an acute/high acuity screen; CT for definitive diagnosis if time permits and CEUS could be used in place where no detection with CT or contraindications to contrast exist. In resource-limited LMIC emergency settings, such an approach provides a pragmatic trade-off between timeliness, diagnostic certainty, and resource stewardship. Future prospective studies may be enhanced by refined imaging algorithms that incorporate decision-support tools and artificial intelligence to maximize modality choice and work flow efficiency.

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