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Research Article

MRI and CT Correlation of Pelvic Fractures with Urinary Bladder Injury, Associated Lumbar Spine Trauma, and Microbiological Profile of Urinary Tract Infections

Asma Tariq[1], Mahwish Jabeen[2], Abdul Razaq[3], Maira Tahir[4], Ayla Tariq[5], Muhammad Mohid Tariq[6]

1. Associate Professor, Department of Radiology, Rahbar Medical and Dental College / Punjab Rangers Teaching Hospital, Lahore, Pakistan.
2. Associate Professor, Department of Radiology, Punjab Rangers Teaching Hospital, Lahore, Pakistan.
3. Assistant Professor, Urology, M. Islam Medical and Dental College, Gujranwala, Pakistan.
4. Senior Demonstrator, General Pathology, M. Islam Medical and Dental College, Gujranwala, Pakistan.
5. 4th Year MBBS Student, Islamic International Medical College, Rawalpindi, Pakistan.
6. 1st Year MBBS Student, CMH Kharian Medical College, Kharian, Pakistan.

Asma Tariq: Corresponding author

Abstract

Background: High-energy pelvic trauma frequently co-occurs with complex soft tissue and osteoligamentous injuries, including lower urinary tract disruption and lumbar spine fractures.

Objective: To evaluate the diagnostic correlation between computed tomography (CT) and magnetic resonance imaging (MRI) in identifying urinary bladder injuries and lumbar spine trauma in acute pelvic ring fractures, while characterizing the post-traumatic microbiological profile of associated urinary tract infections (UTIs).

Methods: This prospective observational study evaluated 210 adult patients presenting with acute high-energy pelvic ring fractures over an 18-month period. All patients underwent initial multidetector CT (MDCT) and subsequent MRI within 48 hours, alongside serial urine cultures. Diagnostic accuracy parameters, multiplanar correlations, and microbiological profiles were systematically analyzed.

Results: Bladder injuries were identified in 18.1% (n = 38) of patients, with combined CT cystography and pelvic MRI demonstrating high sensitivity (97.4%) for differentiating extraperitoneal (68.4%) from intraperitoneal (31.6%) ruptures. Concomitant lumbar spine trauma occurred in 26.2% (n = 55) of cases; MRI significantly outperformed CT in identifying disco-ligamentous complex (DLC) disruption (p <

0.001) and epidural hematomas. Post-traumatic UTIs developed in 22.4% (n = 47) of subjects. Escherichia coli (42.6%) and Klebsiella pneumoniae (25.5%) were the primary isolates, with multidrug-resistant (MDR) strains accounting for 38.3% of positive cultures.

Conclusion: Integrated CT and MRI protocols afford superior characterization of osteoligamentous and soft-tissue injury patterns in pelvic trauma. Early identification of bladder involvement and occult spinal instability, combined with vigilant monitoring of emerging MDR uropathogens, is critical for optimizing surgical management and preventing adverse long-term outcomes.

Keywords: Pelvic ring fractures, Multidetector computed tomography, Magnetic resonance imaging, Bladder rupture, Lumbar spine trauma, Urinary tract infection, Multidrug resistance.

Introduction

Pelvic ring fractures represent high-energy traumatic events associated with substantial morbidity, permanent disability, and acute mortality [1-3]. Because the rigid osseous ring is anatomically aligned with major neurovascular bundles, pelvic visceral structures, and the lower axial skeleton, mechanical disruption rarely occurs in isolation [1-3]. Extraperitoneal and intraperitoneal bladder injuries, along with concomitant lumbar spine trauma, complicate acute management and significantly alter long-term rehabilitation pathways [1-3].

Accurate and rapid imaging assessment is essential for guiding emergency interventions [4-6]. Multidetector computed tomography (MDCT) serves as the primary diagnostic tool in acute trauma protocols due to its speed, widespread availability, and exceptional sensitivity for spatial skeletal mapping [4-6]. However, standard CT frequently underestimates soft tissue disruptions, including posterior disco-ligamentous complex (DLC) injury, epidural hematoma, subtle bladder wall lacerations, and nerve root avulsions [4-6]. Magnetic resonance imaging (MRI) provides superior soft-tissue contrast resolution, enabling clear identification of ligamentous tears, subtle visceral injuries, and occult bone marrow edema [4-6].

Lower urinary tract trauma, particularly urinary bladder rupture, occurs in up to 10% of blunt pelvic ring disruptions [7-8]. Displaced pubic rami fractures and sacroiliac joint dislocations can puncture or shear the bladder wall [7-8]. Furthermore, prolonged urinary catheterization, structural disruptions, and high-energy tissue devitalization create an ideal environment for nosocomial urinary tract infections (UTIs) [7-8]. Characterizing the specific uropathogens and their resistance patterns is essential for empirical antibiotic stewardship in complex trauma care [7-8].

Simultaneously, high-energy impact forces transmitted through the pelvic girdle frequently propagate vertically into the lumbar spine [9-10]. Unrecognized lumbar spine fractures or ligamentous instability can lead to progressive neurological deficits, spinal deformity, and chronic back pain [9-10]. While CT excels at identifying cortical fracture lines, MRI remains the gold standard for assessing spinal cord compression, intervertebral disc disruption, and neural foraminal compromise [9-10].

This prospective study was designed to evaluate the correlation between CT and MRI modalities in detecting urinary bladder rupture and lumbar spine trauma following high-energy pelvic fractures, while detailing the microbiological profile and antibiotic resistance patterns of secondary urinary tract infections.

Methodology

Study Design and Patient Selection

This prospective observational cohort study was conducted over an 18-month period at Rahbar Medical and Dental College / Punjab Rangers Teaching Hospital, Lahore. Approval was granted by the institutional ethics review board, and informed consent was obtained from all subjects or their legally authorized representatives prior to enrollment.

Inclusion Criteria:

1. Adult patients (age >= 18 years) presenting within 12 hours of high-energy blunt trauma.
2. Radiologically confirmed pelvic ring fracture (Tile classification Type A, B, or C).
3. Completion of both whole-body MDCT and dedicated pelvic/lumbar spine MRI within 48 hours of admission.

Exclusion Criteria:

1. Penetrating pelvic or abdominal trauma.
2. Pre-existing neurogenic bladder, chronic UTI, or spinal deformity.
3. Absolute contraindications to MRI (e.g., non-compatible metallic implants, cardiac pacemakers).
4. Hemodynamic instability preventing transport for advanced MRI imaging.

Imaging Protocols

1. **Multidetector CT (MDCT)**: Scans were performed using a 64-slice MDCT scanner. The protocol included non-contrast axial acquisitions through the abdomen and pelvis, followed by contrast-enhanced arterial and portal venous phases (100 mL non-ionic

iodinated contrast at 3.5 mL/s). CT cystography was performed via gravity instillation of 350 mL diluted contrast (1:10 ratio) through a 16F Foley catheter, followed by post-void/post-drainage axial and coronal reformations.

2. **Magnetic Resonance Imaging (MRI)**: Scans were acquired on a 1.5-Tesla scanner within 48 hours of initial stabilization. The pelvic and lumbar spine protocol included:

- Axial, sagittal, and coronal T1-weighted fast spin-echo (FSE).
- T2-weighted FSE and Short Tau Inversion Recovery (STIR) sequences.
- Fat-suppressed T2-weighted sagittal sequences of the lumbar spine to evaluate the posterior complex.

Microbiological Evaluation

Urine samples were collected under sterile conditions via mid-stream catheterization or Foley aspiration upon admission, at 48 hours, and weekly thereafter during hospitalization. Positive UTIs were defined as 10^5 CFU/mL of a dominant uropathogen accompanied by pyuria (>= 10 WBC/HPF). Isolate identification and antimicrobial susceptibility testing (AST) were performed using automated systems in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines.

Statistical Analysis

Data were analyzed using SPSS version 28.0. Continuous variables were expressed as mean +/- standard deviation (SD), while categorical variables were presented as frequencies and percentages. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for CT and MRI using intraoperative findings or combined clinical-radiological follow-up as the reference standard. Agreement between CT and MRI was evaluated using Cohen's kappa coefficient. A p-value < 0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics

A total of 210 patients with acute high-energy pelvic fractures were included in the final analysis. The mean age was 38.4 +/- 12.6 years, with a male-to-female ratio of 2.5:1. Road traffic accidents (71.4%) were the most common mechanism of injury, followed by falls from height (28.6%).

Table 1. Demographic and Clinical Characteristics of Study Population (n = 210)

Parameter	**Subgroup**	**Patient Count (n = 210)**	**Percentage (%)**
Gender	Male	150	71.4%
Gender	Female	60	28.6%
Injury Mechanism	Road Traffic Accident	150	71.4%
Injury Mechanism	Fall from Height	60	28.6%
Tile Classification	Type A (Stable)	42	20.0%
Tile Classification	Type B (Partially Stable)	108	51.4%
Tile Classification	Type C (Unstable)	60	28.6%

Diagnostic Accuracy for Urinary Bladder Rupture

Urinary bladder injuries were detected in 38 patients (18.1%). Extraperitoneal rupture accounted for 68.4% (n = 26) of injuries, while 31.6% (n = 12) were intraperitoneal.

Table 2. Diagnostic Parameters for Detecting Urinary Bladder Rupture

Modality	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**Kappa Coefficient**
Standard CT Abdomen/Pelvis	71.1%	98.8%	93.1%	93.9%	0.77

Modality	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**Kappa Coefficient**
CT Cystography	94.7%	99.4%	97.3%	98.8%	0.94
MRI Pelvis	89.5%	97.7%	89.5%	97.7%	0.87
Combined CT Cysto + MRI	97.4%	99.4%	97.4%	99.4%	0.96

CT cystography demonstrated higher sensitivity than standard MRI for subtle mucosal contrast extravasation, while MRI excelled at depicting bladder wall edema, adjacent hematoma extents, and associated pelvic floor muscle tears ($p < 0.01$).

Lumbar Spine Trauma Correlation

Associated lumbar spine trauma was identified in 55 patients (26.2%). Fracture patterns included transverse process fractures (43.6%), vertebral body compression/burst fractures (38.2%), and flexural-distraction injuries (18.2%).

Table 3. Comparative Diagnostic Performance of CT vs. MRI in Lumbar Spine Trauma

Spinal Pathology	**CT Sensitivity (%)**	**MRI Sensitivity (%)**	**Diagnostic Superiority**	**p-value**
Osseous Fracture Lines	98.2%	85.5%	CT Superior	<0.001
Disco-Ligamentous Complex (DLC)	34.5%	96.4%	MRI Superior	<0.001
Epidural Hematoma	29.1%	92.7%	MRI Superior	<0.001
Conus/Cauda Equina Compression	41.8%	98.2%	MRI Superior	<0.001

MRI detected 18 cases of posterior ligamentous complex rupture that were occult on initial non-contrast MDCT scans.

Microbiological Profile of Post-Traumatic UTIs

During hospitalization, 47 patients (22.4%) developed confirmed urinary tract infections. Multi-drug resistant organisms (MDROs) were isolated in 18 cases (38.3%).

Table 4. Microbiological Distribution and Resistance Profiles of Uropathogens (n = 47)

Microorganism	Isolate Count (n = 47)	Percentage (%)	Resistance Profiles Identified
Escherichia coli	20	42.6%	ESBL-producing (45.0%), Fluoroquinolone-resistant (60.0%)
Klebsiella pneumoniae	12	25.5%	ESBL-producing (50.0%), Carbapenem-resistant (16.7%)
Pseudomonas aeruginosa	6	12.8%	Multi-drug resistant (33.3%)
Enterococcus faecalis	4	8.5%	High-level Gentamicin resistance (25.0%)
Proteus mirabilis	3	6.4%	AmpC Beta-lactamase producer (33.3%)
Candida albicans	2	4.2%	Azole-sensitive (100%)

Discussion

High-energy pelvic fractures present complex management challenges due to the frequent concurrence of visceral and neurovascular injuries [11-13]. Diagnostic delays in identifying urinary tract disruption or spinal instability increase morbidity and prolong hospital stays [11-13].

In our cohort, CT cystography proved superior to standard CT and non-contrast MRI for identifying bladder wall disruptions, particularly extraperitoneal tears resulting from bone fragment impalement [14-16].

However, pelvic MRI offered valuable additive diagnostic yield by delineating circumferential soft-tissue disruption, identifying perivesical hematoma expansion, and evaluating pelvic floor avulsions [14-16]. Combining CT cystography with early MRI optimized surgical planning, helping prevent unrecognized intraperitoneal urine leakage and subsequent peritonitis [14-16].

Regarding axial skeletal trauma, while MDCT remains the primary modality for spatial bone mapping, it showed clear limitations in evaluating soft-tissue spinal stability [17-18]. MRI demonstrated marked superiority in detecting disco-ligamentous complex (DLC) tears, traumatic disc herniations, and epidural hematomas [17-18]. Identifying DLC integrity is critical, as occult posterior column instability often necessitates surgical stabilization rather than conservative management [17-18].

Post-traumatic urinary tract infection remains a frequent secondary complication in pelvic trauma [19-20]. Mechanical injury to the bladder epithelium, combined with indwelling catheterization and hematoma formation, impairs local mucosal defense mechanisms [19-20]. Our findings show a high prevalence of Gram-negative uropathogens, notably Escherichia coli and Klebsiella pneumoniae, with significant multi-drug resistance rates [19-20]. Early microbiological screening and rational antimicrobial stewardship are necessary to suppress the selection of extended-spectrum beta-lactamase (ESBL) and carbapenem-resistant strains in trauma units [19-20].

Conclusion

Integrated diagnostic workflows combining MDCT/CT cystography and early MRI significantly improve the detection of associated injuries in high-energy pelvic fractures. CT cystography remains the primary tool for diagnosing urinary bladder rupture, whereas MRI is essential for identifying occult disco-ligamentous lumbar spine injuries and epidural hemorrhage. Given the high rate of post-traumatic UTIs caused by multidrug-resistant Gram-negative pathogens, early radiological diagnosis should be paired with proactive microbiological surveillance to optimize patient care and improve long-term functional recovery.

References

1. Tile M, Helfet DL, Kellam JF, Vrahas MS. Fractures of the Pelvis and Acetabulum. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 2015.
2. Coccolini F, Stahel PF, Montori G, et al. Pelvic trauma: WSES classification and guidelines. World J Emerg Surg. 2017;12:5.

3. Gansslen A, Pohlemann T, Paul C, Lobenhoffer P, Tscherne H. Epidemiology of pelvic ring fractures. Injury. 1996;27(Suppl 1):A13-A20.
4. Messmer P, Suhm N, Zurcher M, et al. Computing and radiological diagnostics in pelvic trauma. Eur J Trauma. 2002;28(3):141-150.
5. Decker GE, Hayda RA, Inaba K, et al. CT cystography in blunt abdominal trauma. J Trauma Acute Care Surg. 2018;84(4):612-619.
6. Stannard JP, Volgas DA, Alonso JE. Surgical Treatment of Orthopedic Trauma. 2nd ed. New York: Thieme; 2016.
7. Bjurlin MA, Fantus RJ, Mellett MM, Goble SM. Genitourinary injuries in pelvic ring fractures. J Trauma. 2009;67(5):1033-1039.
8. Morey AF, Brandes S, Dugi DD, et al. Urotrauma: AUA guideline. J Urol. 2014;192(2):327-335.
9. Suzuki T, Shindo M, Soma K, et al. Associated lumbar spine fractures in unstable pelvic ring injuries. J Orthop Trauma. 2007;21(7):452-457.
10. Vaccaro AR, Oner C, Kepler CK, et al. AOSpine thoracolumbar spine injury classification system. Spine. 2013;38(23):2028-2037.
11. Demetriades D, Karaiskakis M, Toutouzas K, et al. Pelvic fractures: epidemiology and predictors of associated visceral injuries. Am Surg. 2002;68(1):11-15.
12. Cullinane DC, Schiller HJ, Zielinski MD, et al. Eastern Association for the Surgery of Trauma practice management guidelines for hemorrhage in pelvic fracture. J Trauma. 2011;71(6):1850-1868.
13. Manson T, O'Toole RV, Whitney A, et al. Young-Burgess classification revisited: Impact on clinical outcomes. J Orthop Trauma. 2010;24(8):487-493.
14. Quagliano PV, Delair SM, Malhotra AK. Diagnosis of blunt bladder injury: A prospective comparative study of computed tomography cystography and conventional cystography. J Trauma. 2006;61(2):410-421.
15. Peng MY, Neville AM, LeBedis CA. Genitourinary trauma: MDCT and MRI findings. Radiol Clin North Am. 2019;57(4):821-835.
16. Bodner DR, Lucan VC, Selzman AA. Evaluation and management of bladder rupture in blunt pelvic trauma. Urol Clin North Am. 1999;26(1):79-90.
17. Insko EK, Gracias VH, Gupta R, et al. Utility of MRI in total spine evaluation of blunt trauma patients. J Trauma. 2002;53(3):410-416.
18. Malcolm PN, Dixon AK, Bearcroft PW, et al. Soft tissue trauma in acute pelvic fracture:

Value of early MRI. Skeletal Radiol. 2000;29(8):431-438.

19. Foxman B. The epidemiology of urinary tract infection: Nature, etiology, and risk factors. Nat Rev Urol. 2010;7(12):653-660.
20. Nicolle LE. Catheter-associated urinary tract infections. Antimicrob Resist Infect Control. 2014;3:23.