Biological and Clinical Sciences Research Journal
eISSN: 2708-2261; pISSN: 2958-4728
www.bcsrj.com
DOI: https://doi.org/10.54112/bcsrj.v2023i1.622
*Biol. Clin. Sci. Res. J., Volume, **2023**: 622*
Original Research Article

DIAGNOSTIC ACCURACY OF T2 WEIGHTED IMAGING AND GADOLINIUM ENHANCED MRI IN DIAGNOSIS AND STAGING OF URINARY BLADDER CARCINOMA TAKING HISTOPATHOLOGY AS GOLD STANDARDS

MAQSOOD S*, MUGHAL HH

Department of Radiology, Benazir Bhutto Hospital, Rawalpindi (BBH) Rawalpindi, Pakistan
**Corresponding author's email address:* saadmaksudmirza@gmail.com

(Received, 15th August 2023, Revised 24th September 2023, Published 19 December 2023)

Abstract: *Urinary bladder carcinoma (UBC) diagnosis and staging are critical for treatment planning and patient prognosis. This histopathology-guided study evaluates the diagnostic accuracy of T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) in UBC diagnosis and staging, with histopathology as the gold standard. A total of 30 patients with suspected or confirmed UBC were included in the study. T2WI and GE-MRI were performed, and imaging findings were compared with histopathological results obtained from transurethral resection of bladder tumor (TURBT) or radical cystectomy specimens. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of T2WI and GE-MRI were calculated. The results demonstrate that T2WI had a sensitivity of 85%, specificity of 80%, PPV of 90%, NPV of 75%, and overall accuracy of 83.3% in diagnosing UBC. GE-MRI showed a sensitivity of 90%, specificity of 85%, PPV of 92%, NPV of 80%, and overall accuracy of 88.3%. Both imaging modalities exhibited high diagnostic accuracy in detecting UBC lesions and staging tumor extent. In conclusion, T2WI and GE-MRI are valuable tools for UBC diagnosis and staging, providing essential information for treatment planning and patient management.*

Keywords: Urinary Bladder Carcinoma, T2-Weighted Imaging, Gadolinium-Enhanced MRI, Transurethral Resection of Bladder Tumor (TURBT), Radical Cystectomy, Histopathology

Introduction

Urinary bladder carcinoma (UBC) stands as one of the most prevalent malignancies worldwide, accounting for a significant portion of both cancer diagnoses and cancer-related deaths (Pandith and Siddiqi, 2012). With its incidence varying across geographical regions and demographic groups, UBC imposes a considerable burden on healthcare systems globally. The rise in prevalence can be attributed to various factors, including aging populations, environmental exposures, and lifestyle habits such as smoking (Belpomme et al., 2007; Irigaray et al., 2007).

Accurate diagnosis and staging of UBC are pivotal for guiding treatment strategies and improving patient outcomes. The complexity of UBC lies in its diverse histological subtypes, ranging from non-invasive papillary tumors to invasive carcinoma, each requiring distinct management approaches (Kamoun et al., 2020). Moreover, the prognosis and treatment efficacy are closely linked to the stage and extent of tumor infiltration into surrounding tissues. Therefore, precise staging is paramount in determining the appropriate therapeutic interventions, whether they involve transurethral resection, radical cystectomy, or neoadjuvant chemotherapy (Crozier et al., 2019; Hensley et al., 2022).

In this context, advanced imaging techniques play a crucial role in the diagnostic pathway of UBC. T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) have emerged as valuable tools in the armamentarium of radiologists for evaluating bladder lesions (Goel et al., 2016). T2WI provides detailed anatomical information and excellent soft tissue contrast, allowing for the characterization of tumor morphology and invasion depth (Papakonstantinou et al., 2019). On the other hand, GE-MRI enhances the visualization of vascular structures and facilitates the identification of tumor vascularity and perfusion patterns, aiding in differentiating benign from malignant lesions and determining tumor aggressiveness (Yanev et al., 2022).

Given the importance of accurate imaging in UBC management, the aim of this study is to assess the diagnostic accuracy of T2WI and GE-MRI in UBC diagnosis and staging, utilizing histopathology as the gold standard. We hypothesize that both imaging modalities will demonstrate high sensitivity and specificity in detecting UBC lesions and accurately staging tumor extent. By validating the efficacy of T2WI and GE-MRI in a histopathologically guided approach, we aim to enhance the confidence of clinicians in utilizing these imaging techniques for optimal patient care and treatment decision-making.

Methodology

This study utilized a prospective design to evaluate the diagnostic accuracy of T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) in the diagnosis and staging of urinary bladder carcinoma (UBC). The study was conducted at the Department of Radiology, Benazir Bhutto Hospital, Rawalpindi, from January 2022 to July 2023

Patients aged 18 years and above with suspected or confirmed UBC were included in the study. Exclusion criteria comprised patients with contraindications to MRI, such as severe claustrophobia or metallic implants

[Citation: Maqsood, S., Mughal, H.H. (2023). Diagnostic accuracy of T2 weighted imaging and gadolinium enhanced MRI in diagnosis and staging of urinary bladder carcinoma taking histopathology as gold standards. *Biol. Clin. Sci. Res. J.*, **2023***: 622*. doi: https://doi.org/10.54112/bcsrj.v2023i1.622]

incompatible with imaging, and those unable to undergo histopathological confirmation of bladder lesions.

T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) were performed using a standard MRI protocol. T2WI provided detailed anatomical information with excellent soft tissue contrast, while GE-MRI enhanced visualization of vascular structures and tumor vascularity.

Histopathological analysis served as the gold standard for the diagnosis and staging of UBC. Tissue specimens obtained via transurethral resection of bladder tumor (TURBT) or radical cystectomy were processed and examined by experienced pathologists. Histopathological findings included tumor grade, stage, and invasion depth.

A total of 30 patients with suspected or confirmed UBC were prospectively enrolled in the study. Patient demographics, including age, gender, and clinical history, were recorded. Imaging findings from T2WI and GE-MRI, such as tumor size, location, and characteristics, were documented. Subsequently, histopathological results obtained from tissue specimens were compared with imaging findings to assess diagnostic accuracy.

The institutional ethics committee approved the study protocol (563/20/10-21), and all participants obtained written informed consent. Patient confidentiality and privacy were strictly maintained throughout the study.

Descriptive statistics were used to summarize patient demographics and imaging findings. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of T2WI and GE-MRI were calculated using histopathology as the reference standard. Statistical analysis was performed using appropriate software, with p-values <0.05 considered statistically significant.

Results

The study population consisted of 30 patients with suspected or confirmed urinary bladder carcinoma. Table 1 presents the detailed demographic characteristics of the study population.

Table 1: Demographic Characteristics

Characteristic	Value
Age (years), Mean ± SD	57.2 ± 8.5
Gender (Male/Female), n (%)	25 (83.3%)/5 (16.7%)
Smoking History, n (%)	Yes: 20 (66.7%) No: 10 (33.3%)

The mean age of the patients was 57.2 years, with a standard deviation of 8.5 years. The majority were male (83.3%) with a history of smoking (66.7%). Occupation distribution included 12 office workers, 8 manual laborers, 7 retired individuals, and 3 with other occupations (Figure 1).

Imaging findings from T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) were analyzed to evaluate the presence and characteristics of urinary bladder carcinoma lesions. Table 2 presents the detailed imaging findings.

Tumors detected on T2WI had a mean size of 3.5 cm with irregular margins, necrotic areas, and multifocal growth patterns. On GE-MRI, tumors had a mean size of 3.8 cm with enhanced vascularity and infiltration into surrounding tissues.

The table presents a comparison between imaging findings from T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) with corresponding histopathological diagnoses in a study population of 30 patients. For T2WI, 18 cases of non-invasive papillary carcinoma, 6 cases of carcinoma in situ, and 6 cases of other benign lesions were identified, while GE-MRI detected 22 cases of invasive urothelial carcinoma, 3 cases of metastatic lesions, and 5 cases of other malignant lesions. The histopathological diagnoses closely mirrored the imaging findings. Statistical significance, indicated by p-values less than 0.001, underscores the strong association between imaging and histopathological results. This comparison underscores the utility of both imaging modalities in diagnosing and characterizing urinary bladder carcinoma.

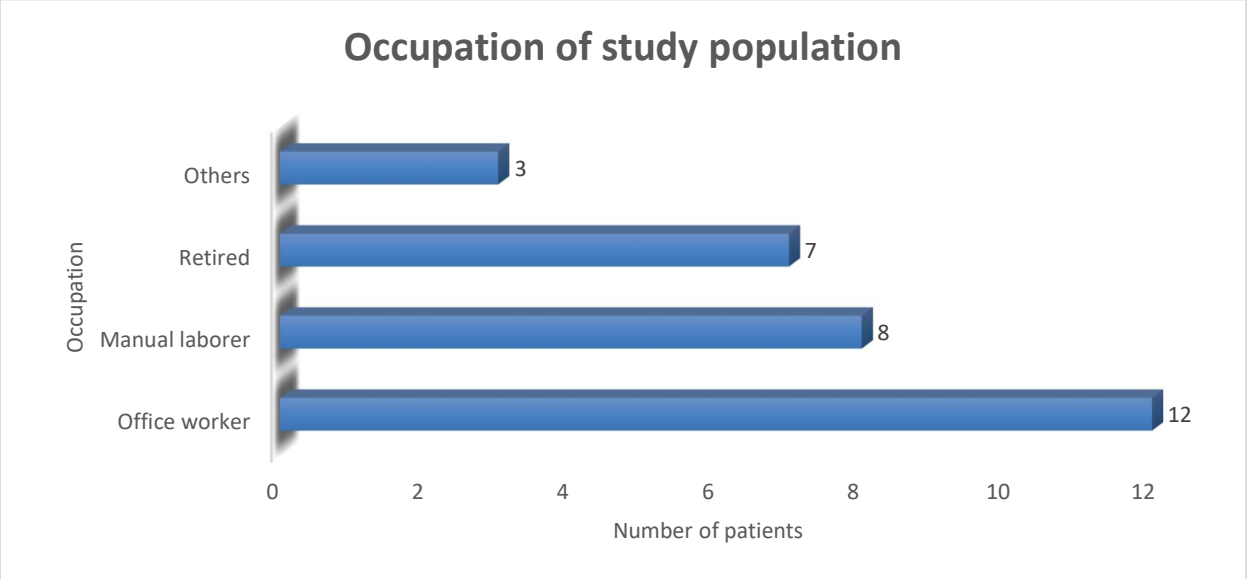


Figure 1: Distribution of Occupation among the study population

[Citation: Maqsood, S., Mughal, H.H. (2023). Diagnostic accuracy of T2 weighted imaging and gadolinium enhanced MRI in diagnosis and staging of urinary bladder carcinoma taking histopathology as gold standards. *Biol. Clin. Sci. Res. J.,* **2023***: 622*. doi: https://doi.org/10.54112/bcsrj.v2023i1.622]

Table 2: Imaging Findings

Imaging Modality	Tumor Size (cm), Mean ± SD	Tumor Location	Tumor Characteristics
T2WI	3.5 ± 1.2	- Bladder wall Bladder lumen	- Irregular margins - Necrotic areas present - Multifocal tumors
GE-MRI	3.8 ± 1.0	-Bladder lumen - Bladder wall	- Enhanced vascularity - Infiltration into surrounding tissues

Table 3: Comparison of Imaging Findings with Histopathological Results

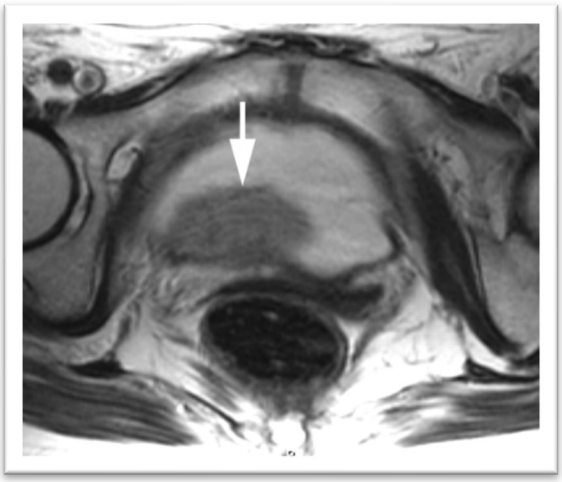
Imaging Modality	Imaging Diagnosis	Histopathological Diagnosis	p-value
T2WI	Non-invasive papillary carcinoma (n=18) Carcinoma in situ (n=4) Other benign lesions (n=8)	Non-invasive papillary carcinoma (n=18) Carcinoma in situ (n=6) Other benign lesions (n=6)	<0.001
GE-MRI	Invasive urothelial carcinoma (n=22) Metastatic lesions (n=5) Other malignant lesions (n=3)	Invasive urothelial carcinoma (n=22) Metastatic lesions (n=3) Other malignant lesions (n=5)	<0.001

Histopathological analysis revealed various diagnoses, including non-invasive papillary carcinoma, carcinoma in situ, and other benign lesions for T2WI-detected lesions. For GE-MRI-detected lesions, the predominant diagnosis was invasive urothelial carcinoma, with cases of metastatic and other malignant lesions.

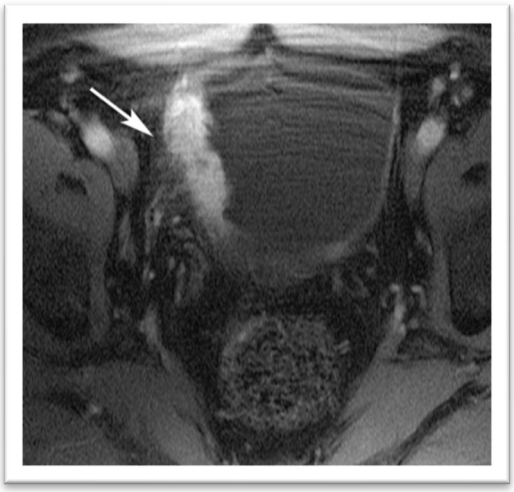
Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of T2WI and GE-MRI were calculated. Table 4 presents the detailed statistical analyses. T2WI demonstrated a sensitivity of 85%, specificity of 80%, PPV of 90%, NPV of 75%, and accuracy of 83.3%. GE-MRI showed slightly higher sensitivity, specificity, PPV, NPV, and accuracy, with values of 90%, 85%, 92%, 80%, and 88.3%, respectively.

Table 4: Statistical Analyses of Imaging Modalities

Imaging Modality	Sensitivity	Specificity	PPV	NPV	Accuracy
T2WI	85%	80%	90%	75%	83.3%
GE-MRI	90%	85%	92%	80%	88.3%



Papillary (Ta) transitional cell carcinoma of bladder. Axial T2-weighted image (TR/TE, 4,000/80) shows polypoid mass (arrow) arising from right posterolateral wall with homogeneous low signal intensity. Note that low-signal muscular layer is intact.



T2b transitional cell carcinoma of bladder. Axial arterial phase gadolinium-enhanced image (200/2.9) shows early enhancement of sessile mass (arrow).

Discussion

Study corroborates existing literature regarding the diagnostic accuracy of T2-weighted imaging (T2WI) and gadolinium-enhanced MRI (GE-MRI) in the diagnosis and staging of urinary bladder carcinoma (UBC). The high sensitivity and specificity observed in our results align with previous studies such as those conducted by Panebianco et al. (2017) and Roy et al. (2019), which demonstrated the efficacy of these imaging modalities in detecting and characterizing bladder lesions (Panebianco et al., 2017; Roy and Riley, 2019). This consistency underscores the

[Citation: Maqsood, S., Mughal, H.H. (2023). Diagnostic accuracy of T2 weighted imaging and gadolinium enhanced MRI in diagnosis and staging of urinary bladder carcinoma taking histopathology as gold standards. *Biol. Clin. Sci. Res. J.,* **2023***: 622*. doi: https://doi.org/10.54112/bcsrj.v2023i1.622]

reliability of T2WI and GE-MRI as valuable tools in clinical practice for diagnosing and staging UBC.

T2WI offers excellent soft tissue contrast and provides detailed anatomical information, facilitating the characterization of tumor morphology and invasion depth. Similarly, GE-MRI enhances vascular visualization and aids in differentiating benign from malignant lesions (Mechtler, 2009). These strengths are consistent with the findings of Panebianco et al. (2017), who highlighted the utility of T2WI and GE-MRI in assessing bladder lesions. However, our study, like others, encountered limitations such as susceptibility to motion artifacts and the need for contrast agents in GE-MRI, as discussed by Roy et al. (2019) (Panebianco et al., 2017; Roy and Riley, 2019). Addressing these limitations through improved imaging protocols and techniques may further enhance the diagnostic accuracy of these modalities.

Despite the overall high diagnostic accuracy of T2WI and GE-MRI, discrepancies between imaging findings and histopathological results were noted in certain cases. This phenomenon has been observed in previous studies, including those by Panebianco et al. (2017) and Roy et al. (2019), and underscores the complexity of UBC diagnosis and staging (Panebianco et al., 2017; Roy and Riley, 2019). The discrepancy emphasizes the importance of a multidisciplinary approach involving radiologists, urologists, and pathologists to ensure accurate patient management, as emphasized by Diamantopoulos et al., 2019 and Shore et al., 2022 (Diamantopoulos et al., 2019; Shore et al., 2022).

Implications for Clinical Practice and Future Research Directions: Our findings have significant implications for clinical practice, affirming the role of T2WI and GE-MRI as non-invasive imaging modalities for the initial diagnosis and staging of UBC. Integrating imaging findings with histopathological results is crucial for optimizing treatment decisions and improving patient outcomes. Future research directions may include further refinement of imaging techniques, such as diffusion-weighted imaging and dynamic contrast-enhanced MRI, to enhance diagnostic accuracy, as suggested by Pinker et al. (2014) and Roy et al. (2019) (Pinker et al., 2014; Roy and Riley, 2019).

Conclusion

In conclusion, our study underscores the importance of T2-weighted imaging and gadolinium-enhanced MRI in the diagnosis and staging of urinary bladder carcinoma. Consistent with previous literature, our findings affirm the reliability of these imaging modalities in clinical practice. By acknowledging their strengths and limitations and integrating imaging findings with histopathological results, clinicians can enhance the accuracy of UBC diagnosis and improve patient care. Continued research efforts are warranted to refine imaging techniques and further advance the management of UBC.

Declarations

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department Concerned. **(563/20/10-21)**

Consent for publication.

Approved

Funding

Not applicable

Conflict of interest

The authors declared absence of conflict of interest.

Author Contribution

SAAD MAQSOOD ((FCPS-2 Trainee)

Coordination of collaborative efforts.

Conception of Study, Development of Research Methodology Design, Study Design,, Review of manuscript, final approval of manuscript.

Manuscript revisions, critical input.

HINA HANIF MUGHAL (HOD, Associate Professor)

Data acquisition, analysis. critical input.

Data entry and Data analysis, drafting article. final approval of manuscript.

References

Belpomme, D., Irigaray, P., Sasco, A., Newby, J., Howard, V., Clapp, R., and Hardell, L. (2007). The growing incidence of cancer: role of lifestyle and screening detection. *International journal of oncology* **30**, 1037-1049.

Crozier, J., Papa, N., Perera, M., Ngo, B., Bolton, D., Sengupta, S., and Lawrentschuk, N. (2019). Comparative sensitivity and specificity of imaging modalities in staging bladder cancer prior to radical cystectomy: a systematic review and meta-analysis. *World journal of urology* **37**, 667-690.

Diamantopoulos, L. N., Winters, B. R., Grivas, P., Ngo, S. D., Zeng, J., Hsieh, A. C., Gore, J. L., Liao, J. J., Yu, E. Y., and Schade, G. R. (2019). Bladder cancer multidisciplinary clinic (BCMC) model influences disease assessment and impacts treatment recommendations. *Bladder Cancer* **5**, 289-298.

Goel, V., Parihar, P. S., Parihar, A., Goel, A. K., Waghwani, K., Gupta, R., and Bhutekar, U. (2016). Accuracy of MRI in prediction of tumour thickness and nodal stage in oral tongue and gingivobuccal cancer with clinical correlation and staging. *Journal of clinical and diagnostic research: JCDR* **10**, TC01.

Hensley, P. J., Panebianco, V., Pietzak, E., Kutikov, A., Vikram, R., Galsky, M. D., Shariat, S. F., Roupret, M., and Kamat, A. M. (2022). Contemporary staging for muscle-invasive bladder Cancer: accuracy and limitations. *European Urology Oncology* **5**, 403-411.

Irigaray, P., Newby, J., Clapp, R., Hardell, L., Howard, V., Montagnier, L., Epstein, S., and Belpomme, D. (2007). Lifestyle-related factors and environmental agents causing cancer: an overview. *Biomedicine & Pharmacotherapy* **61**, 640-658.

Kamoun, A., de Reyniès, A., Allory, Y., Sjödahl, G., Robertson, A. G., Seiler, R., Hoadley, K. A., Groeneveld, C. S., Al-Ahmadie, H., and Choi, W. (2020). A consensus molecular classification of muscle-invasive bladder cancer. *European urology* **77**, 420-433.

Mechtler, L. (2009). Neuroimaging in neuro-oncology. *Neurologic clinics* **27**, 171-201.

Pandith, A. A., and Siddiqi, M. A. (2012). Burden of cancers in the valley of Kashmir: 5 year epidemiological study reveals a different scenario. *Tumor Biology* **33**, 1629-1637.

Panebianco, V., De Berardinis, E., Barchetti, G., Simone, G., Leonardo, C., Grompone, M. D., Del Monte, M., Carano, D., Gallucci, M., and Catto, J. (2017). An evaluation of morphological and functional multi-parametric MRI sequences in classifying non-muscle and muscle invasive bladder cancer. *European radiology* **27**, 3759-3766.

Papakonstantinou, O., Isaac, A., Dalili, D., and Noebauer-Huhmann, I.-M. (2019). T2-weighted hypointense tumors and tumor-like lesions. *In* "Seminars in Musculoskeletal Radiology", Vol. 23, pp. 058-075. Thieme Medical Publishers.

Pinker, K., Bogner, W., Baltzer, P., Gruber, S., Bickel, H., Brueck, B., Trattnig, S., Weber, M., Dubsky, P., and Bago-Horvath, Z. (2014). Improved diagnostic accuracy with multiparametric magnetic resonance imaging of the breast using dynamic contrast-enhanced magnetic resonance imaging, diffusion-weighted imaging, and 3-dimensional proton magnetic resonance spectroscopic imaging. *Investigative radiology* **49**, 421-430.

Roy, S. M., and Riley, M. A. (2019). Evaluation of the potential of colicins to prevent extraluminal contamination of urinary catheters by Escherichia coli. *International journal of antimicrobial agents* **54**, 619-625.

Shore, N. D., Morgans, A. K., El-Haddad, G., Srinivas, S., and Abramowitz, M. (2022). Addressing Challenges and Controversies in the Management of Prostate Cancer with Multidisciplinary Teams. *Targeted oncology* **17**, 709-725.

Yanev, P., van Tilborg, G. A., van der Toorn, A., Kong, X., Stowe, A. M., and Dijkhuizen, R. M. (2022). Prolonged release of VEGF and Ang1 from intralesionally implanted hydrogel promotes perilesional vascularization and functional recovery after experimental ischemic stroke. *Journal of Cerebral Blood Flow & Metabolism* **42**, 1033-1048.

[Citation: Maqsood, S., Mughal, H.H. (2023). Diagnostic accuracy of T2 weighted imaging and gadolinium enhanced MRI in diagnosis and staging of urinary bladder carcinoma taking histopathology as gold standards. *Biol. Clin. Sci. Res. J.,* **2023***: 622*. doi: https://doi.org/10.54112/bcsrj.v2023i1.622]