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Role of Dynamic Contrast Enhanced-MRI In Predicting and Evaluating Treatment Response in Patients with Head and Neck Cancers: Our Experience and Perspective

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Abstract

Despite advances in multimodality treatment strategies for locally advanced squamous cell carcinomas of head and neck (HNSCC) and improvements in loco-regional control, there still exists a considerable variation in response to chemoradiotherapy (CRT). Therefore, early patient stratification is clinically important for optimized and individualized therapeutic regimens necessitating the development of prognostic imaging biomarkers that can accurately predict and assess treatment outcomes. Dynamic contrast enhanced- magnetic resonance imaging (DCE-MRI) allows generation of several imaging parameters from the tracer kinetic analysis of a series of MRI images. These imaging biomarkers provide physiologic information and are promising for noninvasive prognostication and prediction of response in patients with HNSCC. The purpose of this review is to summarize the basic physical principles of DCE-MRI technique and provide an overview of potential utility of DCE-MRI derived parameters in predicting and evaluating treatment response in patients with HNSCC. We will also discuss the existing challenges and limitations of using DCE-MRI in evaluating HNSCC in clinical settings and will discuss possible solutions to avoiding pitfalls in study design, data acquisition, and analysis in future studies.

Keywords: Head and Neck Squamous Cell Carcinoma; Chemoradiation Therapy; Prognostic Biomarkers; Dynamic Contrast Enhanced-MRI; Generalized Kinetic Model; Shutter Speed Model; Volume Transfer Constant; Mean Intracellular Water Molecule Lifetime

Keywords: ADC: Apparent Diffusion Coefficient; AIF: Arterial Input Function; CRT: Chemo-Radiation Therapy; DCE-MRI: Dynamic Contrast Enhanced -MRI; DWI: Diffusion Weighted Imaging; GKM : Generalized Kinetic Model; HNSCC: Squamous Cell Carcinomas Of Head And Neck; K^{trans}: Volume Transfer Constant; SSM : Shutter Speed Model; Ve : Extravascular And Extracellular Volume Fraction; Vp: Plasma Volume Fraction; τi : Mean Intracellular Water Molecule Lifetime

Introduction

Head and neck squamous cell carcinoma (HNSCC) represent the sixth most prevalent cancer worldwide [1]. Patients with HNSCC are usually associated with a poor prognosis and the presence of metastatic cervical lymphadenopathy is considered a negative prognostic indicator in the treatment of HNSCC [2]. Radiation therapy and concurrent chemotherapy is the standard of care for patients with non-resectable HNSCCs [3]. However, the efficacy of chemoradiation therapy (CRT) relies on effective delivery of therapeutic agents and oxygen to neoplastic cells that is often impeded by abnormal blood vessels and the presence of tumor cells farther away from functional vasculature [4]. Thus, development of non-invasive and reliable imaging-based biomarkers offers the promise of investigating the biology of HNSCC and nodal metastases. These physiologic imaging parameters may also serve as biomarkers for early prediction of treatment failure that may enable therapeutic modification, including earlier salvage surgery and upfront intensification of CRT in these patients.

Fundamentals of Dynamic Contrast Enhanced- MRI

Dynamic contrast enhanced (DCE)-MRI is a functional MRI technique that enables the assessment of vascular physiology of tumors [5-8]. DCE-MRI involves rapid and sequential acquisition of fat-suppressed T1-weighted fast gradient echo images before, during and after the intravenous injection of a gadolinium based contrast agent within a tissue of interest. The contrast agent enters the tumor microcirculation through feeding arteries, passes through capillary beds, and extravasates from the intravascular to the extravascular and extracellular space (EES), at a rate, which is determined by tissue perfusion and the permeability of the capillary wall. This extravasation of contrast agent can be quantified either with a semi-quantitative or quantitative analysis.

The semi-quantitative analysis is also based on the premise that tumors demonstrate more rapid and more intense early enhancement. This method involves placing a region of interest (ROI) and tracking the time-intensity curves. There are three types of dynamic contrast enhancement curves: type 1 demonstrates progressive enhancement, type 2 demonstrates rapid enhancement and then plateaus, and type 3 demonstrates rapid enhancement and then washout. Earlier [9] heuristic DCE-MRI parameters such as peak enhancement, maximum upslope, time-to-peak enhancement, and washout slope have been used to characterize head and neck cancers and for predicting and monitoring treatment response. These semi-quantitative parameters are widely used because they are easy to compute without the need of any tracer kinetic modeling. However, these heuristic parameters are highly affected by the gain factor of the acquisition systems, contrast agent volume and injection rate. As a result, these factors can easily change the shape of the signal-intensity time curves precluding accurate estimation of the true concentration of contrast agent in the tissues, and thus making comparison and quantification difficult. Moreover, these descriptive parameters provide no physiologic information about the lesion of interest.

On the other hand, numerous pharmacokinetic models [10-15] have been proposed to extract parameters related to tumor microcirculation by using DCE-MRI. The more commonly used generalized kinetic model (GKM), proposed by Tofts et al. [12] assumes that the water exchange between intravascular and EES compartments is infinitely fast, and that a linear relationship exists between longitudinal relaxation rate (R1) and the concentration of contrast agent in tissues. The Tofts model fits various parameters to the contrast agent concentration-time curve and it also incorporates an arterial input function. This pharmacokinetic model allows estimation of forward volume transfer constant (K^{trans}) determining the flux of gadolinium contrast agent from intravascular space to EES, efflux rate constant (Kep) measuring the rate of efflux of contrast agent back into the plasma from tissue EES, fractional volume of plasma (Vp) and fractional volume of extravascular-extracellular space (Ve). K^{trans} is the most investigated DCE-MRI derived quantitative parameter. Physiologically, the parameter K^{trans} reflects tumor perfusion and vascular permeability. In fact, K^{trans} predominantly represents vascular permeability in a permeability-limited (high flow) situation but represents the blood flow into the tissue in a flow-limited (high permeability) situation. While the parameter Ve is an indirect measure of cellular density and necrosis of a tissue, Vp provides quantification of the plasma volume.

Alternatively, shutter speed model (SSM) [14,15] considers the rate of water exchange between these two compartments is not fast enough (especially in tumors) to equilibrate the effects of contrast agent in the time scales of the MRI acquisition. Under this situation, a linear relationship between R1 and concentration of the contrast agent in the tissue no longer holds true. It has also been reported that SSM provides a more accurate fit to the measured DCE-MRI data than GKM [16]. Moreover, SSM provides a novel imaging parameter known as mean intracellular water molecule lifetime (τi), in addition to the conventional parameters derived from GKM such as K^{trans} and Ve. The parameter τi provides unique information related to tumor cell characteristics such as cell size, and cell membrane permeability [17]. Earlier studies [17-19] have also reported that τi is inversely correlated with cell membrane ion-pump activity, a measure of mitochondrial metabolism suggesting that τi may be a sensitive indicator of cellular energy turnover.

Some studies have reported that increased metabolic activity is associated with lower τi in regions of prostrate, [20,21] and esophageal cancer [22] when compared to the normal tissues. In yet another study, [23] lower τi was observed from normal liver parenchyma (a metabolically more active region) compared to hepatocellular carcinomas. An inverse correlation of τi with EF5, a marker of hypoxia, and a direct correlation of elevated τi regions with high blood flow have also been reported. [24] The unique strength of τi also lies in the fact that it is less sensitive to arterial input function (AIF) scaling variations than Ktrans indicating that τi values are more likely to be reproducible and reliable [25].

Prediction of Treatment Response

While neovascularization is necessary for the growth and spread of HNSCC, it also influences the response to CRT. Therefore, pre-treatment evaluation of HNSCC is important as this would be valuable not only for the radiation oncologist, to target specific sites for a radiotherapy boost, but also for the radiologist to identify sites with a higher likelihood of residual cancer, to determine if these sites need to undergo post-treatment biopsy or can be closely monitored by follow-up imaging. The potential of pretreatment K^{trans} in predicting short-term treatment response [26] as well as survival [27-30] in patients with HNSCC has been reported earlier. These studies suggested that CRT-treated patients with high baseline K^{trans} from metastatic nodes were associated with better prognosis and prolonged survival compared to patients with low baseline K^{trans}. Taken together, these studies support the notion that tumors associated with elevated blood flow and permeable vasculature had higher oxygenation levels, resulting in better access to the chemotherapeutic drug and better radiosensitivity. Shukla-Dave et al. [28] examined the distribution of K^{trans} and showed that high skewness of K^{trans} was associated with lower progression-free and overall survival. The investigators indicated that more heterogeneous tumors, as estimated by high skewness of K^{trans}, were associated with poor prognosis. However, the standard deviation of K^{trans}, another marker of heterogeneity, was neither a significant predictor of progression-free survival nor overall survival.

Most of these studies have focused only on the metastatic cervical lymph nodes because the nodal region is less susceptible to motion-induced artifacts. In a study,[31] from our group, we reported the combined use of diffusion weighted imaging (DWI) and DCE-MRI from primary tumors and metastatic nodes in predicting response to CRT therapy in patients with HNSCC. When apparent

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diffusion coefficient (ADC) and DCE-MRI parameters (K^{trans}, Ve and Vp) from both primary tumors and nodal masses were incorporated into multivariate logistic regression analyses, a considerably higher discriminative accuracy was observed in differentiating responders from non-responders. In a related study, Bernstein et al. [32] also observed significantly higher baseline tumor plasma flow from both primary tumors and lymph nodes in HNSCC patients treated with induction therapy. While these studies indicate that DCE-MRI derived K^{trans} has the potential to guide treatment in HNSCC, our group recently [33] observed that τi may be a better independent prognostic biomarker than K^{trans}. However, incorporation of both pretreatment τi and K^{trans} from metastatic lymph nodes in the multivariate analysis provided the best model to predict overall survival in patients with HNSCC. Taken together, these studies suggest that τi and K^{trans} may serve as potentially useful imaging biomarkers for predicting therapeutic effects of CRT in patients with HNSCC.

The parameter Ve reflects the extravascular extracellular space, which consists of interstitial fluid and connective tissue arranged in a supportive frame structure and is restricted by blood vessel walls and cell plasma membranes. In normal tissues, the extracellular space is balanced in size and shape to ensure adequate supply of nutrients and oxygen to the tissue. However, the composition of the extracellular space of neoplastic tissues is significantly different from that of most normal tissues [34]. In general, the tumor extracellular space is characterized by a large interstitial space, higher collagen concentration, higher interstitial fluid pressure, and higher effective interstitial diffusion coefficient of macromolecules compared with normal tissues. Although the Ve and Vp parameters are physiologically important, previous studies of different cancers [35,36] and our studies [26-31] in HNSCC have failed to show significant differences in Ve and Vp values between responders and non-responders. However, one study has indicated the importance of Ve and Vp as prognostic biomarkers of clinical outcome in patients with osteosarcoma who underwent chemotherapy [37]. Collectively these studies imply that Ve and Vp may not be considered to be reliable as independent parameters. However, given the inherently different physiologic information that Ve and Vp provide, we believe these parameters may play complementary roles in the overall prediction of treatment response when used in conjunction with other parameters.

Evaluation of Treatment Response

Post-treatment DCE-MRI of a residual mass in the primary or nodal bed may improve the diagnostic ability to ascertain if the residual mass still contains viable neoplasm so that primary or nodal resection can be performed before the cancer becomes inoperable. Several studies have shown the utility of DCE-MRI in monitoring for early treatment response in HNSCC. In a previous study [38], an increase in K^{trans} from baseline to a follow-up period was found to be associated with good response to CRT in patients with HNSCC. Similarly, in a prospective study [39], tumor blood volume was significantly higher in patients who went on to achieve local control than in patients who had local failure after two weeks of CRT. In another study [40], post-treatment DCE-MRI demonstrated potential for accurate characterization of residual masses that had failed treatment. Using a large cohort of patients, Lerant et al. [41] also reported the potential of DCE-MRI in analyzing the post-CRT environment in HNSCC.

Current Challenges and Limitations of DCE-MRI

DCE-MRI technique is becoming increasingly common in studying HNSCC. DCE-MRI derived parameters facilitate better understanding of underlying tumor microenvironment. However, there are still some unresolved issues when implementing DCE-MRI in routine clinical practice. DCE-MRI data from head and neck region is sensitive to voluntary and involuntary motion such as breathing and swallowing, therefore, motion-correction algorithms should be used on the raw DCE image data to correct for any in-plane rotational motion artifacts. It has been observed that DCE-MRI parameters are inevitably influenced by various hemodynamic factors, types of contrast agents, signal to noise ratio and spatial resolution of images. For instance, K^{trans} is determined by blood flow and vascular permeability.

In conditions of high leakage or low-molecular-weight contrast agent administration, K^{trans} depends almost entirely on blood flow. Increased acquisition time with low temporal resolution results in underestimation of K^{trans}. In multicenter clinical trials, even minor differences of benchmarked standards may result in significant changes in parameters. These variables include (1) MR scanners (field strength, performance of gradient system, and selection of pulse sequences); (2) imaging acquisition protocols (acquisition parameters, spatial and temporal resolution, and coverage); (3) contrast agent administration (dynamic bolus, injection dose and rate, and timing); and (4) postprocessing methods (semiquantitative or pharmacokinetic model selection, AIF determination, and region of interest/histogram/voxel-wise analysis). Collectively, these factors across institutions hamper the accuracy and reproducibility of findings and thus inhibit translation of this powerful and useful imaging modality into a routine clinical setting [42].

To address these issues, the Quantitative Imaging Biomarkers Alliance (QIBA) of the Radiological Society of North American (RSNA) established an updated technical guideline for DCE-MRI data acquisition and analysis in 2015. We believe that these proposed recommendations will significantly reduce variability and will allow interpretation of imaging results from different centers with more reliability and confidence.

Conclusion and Future Perspectives

Despite some clinical limitations and unsolved issues, DCE-MRI is a valuable imaging technique that provides quantitative and biologically relevant information related to tumor microenvironment that can help to predict and evaluate treatment outcome and survival in patients with HNSCC. However, it is critical to standardize imaging protocols for fast-tracking the translation

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of DCE-MRI into routine clinical applications. Follow-up studies should be performed using the same equipment and DCE-MRI acquisition and processing methods. Further progress in this field requires data sharing and large multi-center collaborative validation studies.

References

1. Parkin DM, Bray F, Ferlay J, Pisani P (2005) Global Cancer Statistics, 2002. A Cancer Journal for Clinicians 55(2): 74-108.
2. Chen CC, Lin JC, Chen KW (2015) Lymph node ratio as a prognostic factor in head and neck cancer patients. Radiat Oncol 10: 181.
3. Santuray RT, Johnson DE, Grandis JR Grandis (2018) New Therapies in Head and Neck Cancer. Trends Cancer 4(5): 385-396.
4. Klausner G, Troussier I, Blais E, Carsuzaa F, Zilli T, et al. (2019) Neck management in head and neck squamous cell carcinomas: where do we stand? Med Oncol 36(5): 40.
5. Bernstein JM, Homer JJ, West CM (2014) Dynamic contrast-enhanced magnetic resonance imaging biomarkers in head and neck cancer: potential to guide treatment? A systematic review. Oral Oncol 50(10): 963-970.
6. Kabadi SJ, Fatterpekar GM, Anzai Y, Mogen J, Hagiwara M, et al. (2018) Dynamic Contrast-Enhanced MR Imaging in Head and Neck Cancer. Magn Reson Imaging Clin N Am 26(1):135-149.
7. Deng J, Wang Y (2017) Quantitative magnetic resonance imaging biomarkers in oncological clinical trials: Current techniques and standardization challenges. Chronic Dis Transl Med 3(1): 8-20.
8. Dijkhoff RAP, Beets-Tan RGH, Lambregts DMJ, Beets GL, Maas M (2017) Value of DCE-MRI for staging and response evaluation in rectal cancer: A systematic review. Eur J Radiol 95: 155-168.
9. Hoskin PJ, Saunders MI, Goodchild K, Powell ME, Taylor NJ, et al. (1999) Dynamic contrast enhanced magnetic resonance scanning as a predictor of response to accelerated radiotherapy for advanced head and neck cancer. Br J Radiol 72: 1093-1098.
10. Rijpkema M, Kaanders JH, Joosten FB, van der Kogel AJ, Heerschap A (2001) Method for quantitative mapping of dynamic MRI contrast agent uptake in human tumors. J Magn Reson Imaging 14(4): 457-463.
11. Tofts PS, Kermode AG (1991) Measurement of the blood-brain barrier permeability and leakage space using dynamic MR imaging. 1. Fundamental concepts. Magn Reson Med 17(2): 357-367.
12. Tofts PS (1997) Modeling tracer kinetics in dynamic Gd-DTPA MR imaging. J MagnReson Imaging 7(1): 91-101.
13. Brix G, Semmler W, Port R, Schad LR, Layer G, et al. (1991) Pharmacokinetic parameters in CNS Gd-DTPA enhanced MR imaging. J Comput Assist Tomogr 15(4): 621-628.
14. Landis CS, Li X, Telang FW, Molina PE, Palyka I, et al. (1999) Equilibrium transcytolemmal water-ex-change kinetics in skeletal muscle in vivo. Magn Reson Med 42(3): 467-478.
15. Yankeelov TE, Rooney WD, Li X, Springer CS Jr (2003) Variation of the relaxographic "shutter-speed" for transcytolemmal water exchange affects the CR bolus-trackingcurve shape. Magn Reson Med 50(6): 1151–1169.
16. Kim S, Quon H, Loevner LA, Rosen MA, Dougherty L, et al. (2007) Transcytolemmal water exchange in phar-macokinetic analysis of dynamic contrast-enhanced MRI data in squamouscell carcinoma of the head and neck. J Magn Reson Imaging 26: 1607-1617.
17. Springer CS Jr, Li X, Tudorica LA, Oh KY, Roy N, et al. (2014) Intratumor mapping of intracellular water lifetime: metabolic images of breast cancer? NMR Biomed 27(7): 760-773.
18. Zhang Y, Poirier-Quinot M, Springer CS Jr, Balschi JA (2011) Active trans-plasma membrane water cycling in yeast is revealed by NMR. Biophys J 101(11): 2833-2842.
19. Nath K PR, Nelson DS, Pickup S (2014) Acute changes in cellular-interstitial water exchange rate in DB-1 melanoma xenografts after lonidamine administration as a marker of tumor energetics and ion transport. Proc Intl Soc Magn Reson Med, Italy.
20. Li X, Priest RA, Woodward WJ, Siddiqui F, Beer TM, et al. (2012) Cell membrane water exchange effects in prostate DCE-MRI. J Magn Reson 218: 77-85.
21. Lowry M, Zelhof B, Liney GP, Gibbs P, Pickles MD, et al. (2009) Analysis of prostate DCE-MRI: comparison of fast exchange limit and fast exchange regimen pharmacokinetic models in the discrimination of malignant from normal tissue. Invest Radiol 44(9): 577-584.
22. Chang EY, Li X, Jerosch-Herold M, Priest RA, Enestvedt CK, et al. (2008) The evaluation of esophageal adenocarcinoma using dynamic contrast-enhanced magnetic resonance imaging. J Gastrointest Surg 12(1): 166-175.
23. Jajamovich GH, Huang W, Besa C, Li X, Afzal A, et al. (2016) DCE-MRI of hepatocellular carcinoma: perfusion quantification with Tofts model versus shutter-speed model--initial experience. MAGMA 29(1): 49-58.
24. Koch CJ, Jenkins WT, Jenkins KW, Yang XY, Shuman AL, et al. (2013) Mechanisms of blood flow and hypoxia production in rat 9L-epigastric tumors. Tumor Microenviron Ther 1: 1-13.
25. Li X, Cai Y, Moloney B, Chen Y, Huang W, et al. (2016) Relative sensitivities of DCE-MRI pharmacokinetic parameters to arterial input function (AIF) scaling. J Magn Reson 269: 104-112.
26. Kim S, Loevner LA, Quon H, Kilger A, Sherman E, et al. (2010) Prediction of response to chemoradiation therapy in squamous cell carcinomas of the head and neck using dynamic contrast-enhanced MR imaging. Am J Neuroradiol 31(2): 262-268.
27. Chawla S, Kim S, Loevner LA, Hwang WT, Weinstein G, et al. (2011) Prediction of disease-free survival in patients with squamous cell carcinomas of the head and neck using dynamic contrast-enhanced MR imaging. Am J Neuroradiol 32(4): 778-784.
28. Shukla-Dave A, Lee NY, Jansen JF, Thaler HT, Stambuk HE, et al. (2012) Dynamic contrast-enhanced magnetic resonance imaging as a predictor of outcome in head-and-neck squamous cell carcinoma patients with nodal metastases. Int J Radiat Oncol Biol Phys 82(5): 1837-1844.
29. Ng SH, Liao CT, Lin CY, Chan SC (2016) Dynamic contrast-enhanced MRI, diffusion-weighted MRI and ^{18}F-FDG PET/CT for the prediction of survival in oropharyngeal or hypopharyngeal squamous cell carcinoma treated with chemoradiation. Eur Radiol 26(11): 4162-4172.
30. Lowe NM, Kershaw LE, Bernstein JM, Withey SB, Mais K, et al. (2018) Pre-treatment tumour perfusion parameters and initial RECIST response do not predict long-term survival outcomes for patients with head and neck squamous cell carcinoma treated with induction chemotherapy. PLoS One 13(3): e0194841.
31. Chawla S, Kim S, Dougherty L, Wang S, Loevner LA, et al. (2013) Pretreatment diffusion-weighted and dynamic contrast-enhanced MRI for prediction of local treatment response in squamous cell carcinomas of the head and neck. Am J Roentgenol 200: 35-43.
32. Bernstein JM, Kershaw LE, Withey SB, Lowe NM, Homer JJ, et al. (2015) Tumor plasma flow determined by dynamic contrast-enhanced MRI predicts response to induction chemotherapy in head and neck cancer. Oral Oncol 51(5): 508-513.
33. Chawla S, Loevner LA, Kim SG, Hwang WT, et al. (2018) Dynamic Contrast-Enhanced MRI-Derived Intracellular Water Lifetime (τ_i): A Prognostic Marker for Patients with Head and Neck Squamous Cell Carcinomas. Am J Neuroradiol 39(1): 138-144.

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34. Jain RK (1987) Transport of molecules in the tumor interstitium: a review. Cancer Res 47(12): 3039-3051.

35. Gollub MJ, Gultekin DH, Akin O, Do RK, Fuqua JL, et al. (2012) Dynamic contrast enhanced-MRI for the detection of pathological complete response to neoadjuvant chemotherapy for locally advanced rectal cancer. Eur Radiol 22(4): 821-831.

36. Zahra MA, Tan LT, Priest AN, Graves MJ, Arends M, et al. (2009) Semiquantitative and quantitative dynamic contrast-enhanced magnetic resonance imaging measurements predict radiation response in cervix cancer. Int J Radiat Oncol Biol Phys 74(3): 766-773.

37. Guo J, Reddick WE, Glass JO, Ji Q, Billups CA, et al. (2012) Dynamic contrast-enhanced magnetic resonance imaging as a prognostic factor in predicting event-free and overall survival in pediatric patients with osteosarcoma. Cancer 118(15): 3776-3785.

38. Chikui T, Kitamoto E, Kawano S, Sugiura T, Obara M, et al. (2012) Pharmacokinetic analysis based on dynamic contrast-enhanced MRI for evaluating tumor response to preoperative therapy for oral cancer. J Magn Reson Imaging 36(3): 589-597.

39. Cao Y, Popovtzer A, Li D, Chepeha DB, Moyer JS, et al. (2008) Early prediction of outcome in advanced head-and-neck cancer based on tumor blood volume alterations during therapy: a prospective study. Int J Radiat Oncol Biol Phys 72(5): 1287-1290.

40. King AD, Chow SK, Yu KH, Mo FK, Yeung DK, et al. (2015) DCE-MRI for Pre-Treatment Prediction and Post-Treatment Assessment of Treatment Response in Sites of Squamous Cell Carcinoma in the Head and Neck. PLoS One 10: e0144770.

41. Lerant G, Sarkozy P, Takacsi-Nagy Z, Polony G, Tamas L, et al. (2015) Dynamic Contrast-Enhanced MRI Parameters as Biomarkers in Assessing Head and Neck Lesions After Chemoradiotherapy Using a Wide-Bore 3 Tesla Scanner. Pathol Oncol Res 21(4): 1091-1099.

42. Sullivan DC, Obuchowski NA, Kessler LG, Raunig DL, Gatsonis C, et al. (2015) Metrology standards for quantitative imaging biomarkers. Radiology 277(3): 813-825.

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