Letters to the Editor

Are Radiopaque Beads a Real Advantage?

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Editor:

We read with great interest the article by Dr Mikhail and colleagues in the November 2018 issue of *Radiology* (1) entitled "Mapping Drug Dose Distribution on CT Images Following Transarterial Chemoembolization with Radiopaque Drug-Eluting Beads in a Rabbit Tumor Model." In this animal study using radiopaque beads, Dr Mikhail and colleagues were able to demonstrate a direct correlation between bead attenuation measured at CT examination 1 hour after transarterial chemoembolization (TACE), bead volume in explanted liver at histologic examination, and concentration of doxorubicin in the surrounding parenchyma. Based on these findings, the authors suggest that attenuation value could be a useful tool for customizing therapy and tailoring targeted drug delivery.

Despite the clear advantages depicted within this novel research, we would like to raise some points regarding both the timing of imaging and the selection of the imaging modality and their potential clinical implications.

Currently, as suggested by several research groups, postprocedural bead deposition can be assessed immediately at the end of the procedure, independently using radiopaque beads and without patient repositioning, directly in the angiographic suite with cone-beam CT instead of conventional CT. This unenhanced acquisition can depict deposition of the embolic agent used (2). If performed after contrast material administration (namely, dual-phase cone-beam CT acquisition), it can demonstrate tumor enhancement reduction (3). In addition, the identification of filling defects in the tumor's contrast material retention could permit immediate treatment adjustment (eg, adjunctive feeding vessel embolization), thus improving treatment outcome (4).

Finally, we would like to discuss with Dr Mikhail and colleagues the choice of the best imaging modality for surveillance after a procedure performed with radiopaque beads. It is worth emphasizing that the employment of such a device can determine beam-hardening artifacts at follow-up CT examination that do not occur after chemoembolization with radiolucent beads. This represents a major constraint in assessing the presence or absence of residual vital tissue at CT, thus requiring MRI surveillance.

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Response

From
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We thank Dr Lucatelli and colleagues for their comments on our work evaluating the use of x-ray attenuation on CT images as a surrogate marker for spatial drug dosimetry after embolization with drug-eluting radiopaque beads (1). In our study, we correlated bead attenuation and volume measured on CT scans with drug levels representing the sum of drug present within the beads and that which had diffused into the surrounding tissue, without differentiating between these two compartments. A single, 1-hour time point was selected to allow washout of liquid contrast material, minimizing its contribution to the measured attenuation on images. Data on the rate of contrast material clearance after embolization suggest this analysis might be performed at an earlier timepoint by using intraprocedural cone-beam CT (2).

While we used delayed CT and micro-CT to prove the concept and to develop the model, translation to cone-beam CT may lead to software solutions to evaluate and guide drug delivery, allowing for immediate real-time intraprocedural iterative modifications in treatment. The merits of cone-beam CT after chemoembolization with and without contrast material administration are well proven. Fusion or subtraction of

these cone-beam CT images may delineate spatial distribution of radiopaque beads in relation to enhancing tumor and thus help identify residual tumor tissue at risk for undertreatment (3).

Finally, Dr Lucatelli and colleagues suggest that beam-hardening artifact may compromise CT examination such that MRI surveillance is required. We have not seen significant beam-hardening artifact on intraprocedural cone-beam CT or follow-up CT images in our nearly 3 years of clinical experience with radiopaque beads. Metal artifact reduction or stent reconstruction algorithms may be helpful if this were to be a problem.

The clinical utility of radiopaque beads for drug-eluting bead TACE is still being defined. However, their visibility at CT and cone-beam CT can provide information regarding vessel embolization and local drug dose and distribution in relation to the tumor. Dosimetry is possible because the drug is delivered from and therefore co-localized with the beads. In contrast, drug levels do not correspond spatially with iodized oil during TACE (4). Knowledge of drug location may help personalize and optimize chemoembolization. Furthermore, information on spatial drug location may inform or clarify the debate on relative effects of drug versus ischemia in TACE.

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