COMMENTARY

Understanding of Flow Allows Better Tumor Microsphere Coverage

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ABBREVIATIONS

BD = bolus delivery, DSD = dual-syringe delivery

In this issue of the *Journal of Vascular and Interventional Radiology*, Miller et al (1) developed an in vitro platform that consisted of a hepatic arterial tree and a tumor vascular model to compare 2 different methods for the administration of yttrium-90 glass microspheres: conventional bolus delivery (BD) and dual-syringe delivery (DSD). The authors concluded that the latter resulted in a more uniform and deeper distribution of the microspheres in their platform, potentially portending more effective deposition in actual tumors.

By comparing the different administration methods, the authors implicitly analyzed the importance of microsphere concentration for injection. It is believed that it could also be interesting to study the microsphere concentration in the flow reaching distal vessels, as Aramburu et al (2) recently suggested. This microsphere concentration in the flow depends on variables that can be controlled by an interventional radiologist (ie, the microsphere concentration for injection and injection velocity) and those that cannot be controlled (ie, blood flow and arterial geometry downstream of injection). A study of the microsphere concentration for injection and its impact on the microsphere concentration in the flow and on the final deposition of microspheres could allow for the optimization of the distribution of resin and glass microspheres. Indeed, the spatial density (ie, the number of microspheres deposited per unit treated volume) and specific activity of microspheres are variables that could be optimized to maximize the tumor-absorbed dose and, therefore, treatment efficacy (3).

In order to complement the current discussion of the authors, it would be very interesting to further analyze the blood-mimicking fluid flow and injection flow (with no microspheres) in the vicinities of the injection location (ie, the distal trifurcation in the study by Miller et al (1)) and in a tumor model because microsphere distribution is highly influenced by fluid flow. To do so, computational fluid dynamics simulations could be used (4). Alternatively, dyed water could be injected using a microcatheter to assess the behavior of the flow visually. This can lead to discussion about whether the mesoscale vasculature (ie, initial part of the tumor model, where the cross-sectional area increases to later decrease in the microvascular trees) produces physiologically realistic flow.

Additionally, the data from the article can be analyzed to extract useful information and design future research. For this specific in vitro platform as well as hemodynamic and injection conditions, the microcatheter-to-arterial flow ratio was approximately 0.7 at the injection location for DSD and approximately 1.4 for BD, meaning that the microcatheter flow was 0.7 or 1.4 times the flow through the artery, respectively, depending on the delivery method. Moreover, the microcatheter-to-arterial flow velocity ratio was approximately 4.7 for DSD and 9.4 for BD, meaning that the microcatheter flow velocity was 4.7 or 9.4 times the arterial flow velocity, respectively, depending on the delivery method. Thus, according to these 2 parameters, the normal hemodynamics was altered to a greater extent with BD than with DSD in this particular case, which may have had detrimental effects on the distribution and deposition of the microspheres. In this study, downstream of injection, the arterial and microcatheter flow encountered a trifurcation in which the artery feeding the tumor was located at the lowest-resistance location (ie, with no curvature and in line with the parent vessel) and received 80% of the total flow of the parent vessel. In other patient-specific cases, the on-target deposition could be different from the reported 85% depending on the vasculature and hemodynamic conditions downstream of the injection location.

In its current form, the in vitro platform allows for the analysis of the final microsphere distribution. Incorporating a system to record the dynamic deposition of microspheres would help us better understand how microspheres flow through the arteries and eventually deposit in the in vitro platform.

The conclusions of this study are very interesting. However, they are solely based on in vitro experiments. Before incorporating them in the clinical setting, they should be tested in vivo. Those investigations will be very

J Vasc Interv Radiol 2022; xxx:1–2
https://doi.org/10.1016/j.jvir.2022.09.009

useful in paving the way for developing a computer-guided, patient-specific treatment-planning platform to assist multidisciplinary teams that plan not only radioembolization but also other catheter-based intra-arterial procedures.

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J.A. and R.A. have received speaker honoraria from Sirtex Medical and have received research fees from Terumo and Sirtex Medical. M.R.-F. and J.I.B. have received consultation fees and speaker honoraria from Sirtex Medical.

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