The rapid development of nanomedicine offers innovative approaches to improving current cancer diagnostic and therapeutic technologies [1,2]. Among the numerous challenges faced by the field of oncology, more efficiently controlled drug release and drug penetration into solid tumors are now thought possible by the use of magnetic nanoparticles [3-6]. A recent study by Kong and colleagues [7] documents the successful creation of a drug delivery system using nanocapsules that provide on-demand drug release by external magnetic stimuli. Both in vitro and in vivo studies using MT2 mouse breast cancer cell models demonstrate that the magnetic targeting of these nanocapsules allows for deep tumor penetration and subsequent on-demand release of the drug cargo, significantly reducing tumor cell viability.

Abstract
A recent study published in Nano Letters documents the synthesis and performance of porous silica nanocapsules filled with magnetic nanoparticles as a controllable magnetic drug delivery vector. Under a remotely applied radiofrequency magnetic field, these nanocapsules demonstrate on-off switchable release of the internally loaded drug payload. Both in vitro and in vivo studies using MT2 mouse breast cancer cell models demonstrate that the magnetic targeting of these nanocapsules allows for deep tumor penetration and subsequent on-demand release of the drug cargo, significantly reducing tumor cell viability.

The advantages of this drug delivery technology are highly promising for cancer therapy. First, the system provides a highly efficient means to safely deliver anticancer drugs to deep tumor sites via magnetic targeting. As noted by the authors, the majority of the administered nanocapsules reach the target site with minimal amounts accumulated in the liver and spleen. Secondly, the silica shell and drug payload of the SiMNCs can be modified to allow for customizable drug administration. The exterior of the porous silica shell can be covalently functionalized with various biomolecules for targeting purposes. In addition to anticancer drugs and fluorophores, other
molecular cargos, such as microRNAs, peptides, and hormones, can be potentially loaded into and released from the SiMNC particles. Lastly, the magnetic nanoparticles within the SiMNCs are superparamagnetic and can therefore be visualized by T2-weighted MRI. This capability should be further explored in order to assess SiMNCs as effective ‘theranostic’ agents.

One drawback in the system design is the inability to target tumors that have not yet been located or those that are not superficially accessible. Currently, the location of the tumor must be known so that an external magnetic field can be applied to the target area to allow for nanocapsule accumulation. The MRI capability of the iron oxide nanoparticles and the possibility of attaching targeting groups to the SiMNC exterior may remedy this limitation. The SiMNCs may not efficiently target a deep-tissue tumor since the applied magnetic field strength decreases with distance, and this could lead to drug accumulation in the region between the external magnet and the tumor. Surgically implanting a magnet closer to the tumor site, as demonstrated in similar studies [9], is a possible way to circumvent this problem.

Several issues must be addressed before clinical implementation. It is important to determine whether the release of the drug payload is a result of localized heating of the magnetic nanoparticles or an increase in the ambient temperature of the SiMNC surroundings. As the authors suggest, a quantitative analysis of the heat generation and conduction within the nanocapsules is necessary to better understand the drug release mechanism. Furthermore, it must also be confirmed that the cell death observed after RF treatment is due only to drug release and not to magnetic hyperthermia produced by the magnetic nanoparticles. As all other nanoparticles, the biodistribution, biodegradation, and in vivo efficiency of the SiMNCs under more strenuous physiological conditions, such as blood flow, must also be evaluated before use in human patients can be realized.

**Abbreviations**

MRI, magnetic resonance imaging; RF, radiofrequency; SiMNC, silica magnetic nanocapsule.

**Competing interests**

The authors declare that they have no competing interests.

References

1. Kim BYS, Rutka JT, Chan WCW: Current concepts: nanomedicine. N Engl J Med 2010, 363:2434-2443.
2. Cuenca AG, Jiang H, Hochwald SN, Delano M, Cance WG, Grobmyer SR: Emerging implications of nanotechnology on cancer diagnostics and therapeutics. Cancer 2006, 107:459-466.
3. Arruebo M, Fernández-Pacheco R, Ibarra MR, Santamaría J: Magnetic nanoparticles for drug delivery. Nano Today 2007, 2:32-32.
4. Kloostergaard J, Bankson J, Auzenne E, Gibson D, Yull W, Seeley CE: Magnetic vectoring of magnetically responsive nanoparticles within the murine peritoneum. J Magn Magn Mater 2007, 311:330-335.
5. Hoare R, Santamaría J, Goya GF, Irusta S, Lin D, Lau S, Padera R, Langer R, Kohane DS: A magnetically triggered composite membrane for on-demand drug delivery. Nano Lett 2009, 9:3651-3657.
6. Thomas CR, Ferris DP, Lee J-H, Choi E, Cho MH, Kim ES, Stoddart JF, Shin J-S, Cheon J, Zink J: Noninvasive remote-controlled release of drug molecules in vitro using magnetic actuation of mechanized nanoparticles. J Am Chem Soc 2010, 132:10623-10625.
7. Kong SD, Zhang W, Lee JH, Brammer K, Lal R, Karin M, Jin S: Magnetically vectored nanocapsules for tumor penetration and remotely switchable on-demand drug release. Nano Lett 2010, 10:5088-5092.
8. Hilger I, Hengt R, Kaiser WA: Use of magnetic nanoparticle heating in the treatment of breast cancer. IEEE Proc Nanobiotechnol 2005, 152:33-39.
9. Kempe H, Kempe M: The use of magnetite nanoparticles for implant-assisted magnetic drug targeting in thrombolytic therapy. Biomaterials 2010, 31:9499-9510.

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