Acta Radiologica Open
4(9) 1–2
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DOI: 10.1177/2058460115603876
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Response from the authors of the original article. Comment to: Månsson C, Nilsson A, Karlson B-M. Severe complications with irreversible electroporation of the pancreas in the presence of a metallic stent: a warning of a procedure that never should be performed

Regarding Scheffer, Voge, van den Bos et al.'s comments

Christopher Månsson[1], Anders Nilsson[2], Daniel Månsson[3] and Britt-Marie Karlson[1]

First of all, thank you for reading and noticing our article "Severe complications with irreversible electroporation of the pancreas in the presence of a metallic stent: a warning of a procedure that never should be performed" (1). In this article we described a case of a woman with a locally advanced pancreatic cancer. She had been treated in a private center with irreversible electroporation (IRE). As you point out, we did not and could not provide any details regarding the IRE settings or needle positions as this information is not available to us. However, the severe outcome mandated thoughts on whether the IRE treatment caused the complications. In our experience this is not the normal pathology for a locally advanced pancreatic cancer. Therefore we suspect that the IRE treatment caused the injuries. As we stated in our article, "we cannot know whether the IRE treatment alone or the existence of the metallic stent in the treated tissue volume was the cause of the bowel perforation and pseudoaneurysm formation. However, the sites of the injuries are suggestive."

We disagree with the theoretical argument made by Scheffer et al. and the conclusion drawn regarding direct joule heating of the stent. It is stated that the stent cannot be directly heated through ohmic losses (i.e. Joule heating) in the metal as it is believed that currents are not formed inside the material. This argument made by Scheffer et al. would lead to the fact that no signals would be induced in a receiving antenna.

First, non-static electromagnetic fields created (e.g. by IRE) will penetrate a solid cylinder; see Section 8.1 in Jackson (2) but it will have attenuated 1/e (approximately 37%) at the so called "skin depth". The skin depth (in meters), δ, of an electromagnetic field of frequency f is given by $\delta = 1/\sqrt{(\pi f \mu \sigma)}$, where μ and σ are the magnetic permeability and the electric conductivity of the material, respectively. An electromagnetic field will penetrate any material with finite μ and σ (i.e. not superconducting) and, thus, set up circulating (eddy) currents inside the material (due to the voltage gradient formed in the material due to the attenuation of the electromagnetic field; see Section 5.18 in Jackson (2)).

Second, the stent is not a solid cylinder but a mesh (i.e. "grid"). At wavelengths that are very long compared to the mesh size and diameter of the stent, the stent can shield the interior from exterior fields. However, close to the inside boundary of the mesh (i.e. surface) the electromagnetic field leaks through and can couple (i.e. deliver energy) to objects inside (see Section 3.13 in Jackson (2)). This shielding via a mesh is created by circulating currents formed in the mesh (3,4). Thus, however one views the stent, currents

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are formed inside them which means ohmic losses and joule heating.

The critical question is if these losses are enough to considerably heat the stent *in vivo*, which is highly dependent on the parameters of the stent (material and dimensions), the electromagnetic field (frequency and propagation mode), and the thermodynamic parameters of the surrounding tissue. It is true, as stated by Scheffer et al., that surface currents are mostly non-existent however, this does not mean that there are no currents inside the material.

Scheffer et al. also provide an experimental argument with IRE treatment of phantom tissue from an unpublished study. We think that although they did not see any heating if a stent was present in an experimental setting, this does not prove that it did not happen in the case we presented with a human patient in a clinical setting.

Finally, since this a new treatment and this issue is not resolved we still think that caution is important when using a new invasive treatment and that IRE should be avoided when a metallic stent is present. We agree with Scheffer et al. that further studies are needed and we are with great interest looking forward to reading their study with IRE in tissue phantom with and without metallic stents.

References

1. Månsson C, Nilsson A, Karlson B-M. Severe complications with irreversible electroporation of the pancreas in the presence of a metallic stent: a warning of a procedure that never should be performed. Acta Radiologica Short Reports 2014;311:1–3.
2. Jackson JD. *Classical Electrodynamics*, 3rd ed. Hoboken, NJ: John Wiley & Sons, Inc, 1999.
3. Casey KF. Electromagnetic shielding behavior of wire-mesh screens. IEEE Transactions on Electromagnetic Compatibility 1988;30:298–306.
4. Månsson D, Ellgardt A. Comparing analytical and numerical calculations of shielding effectiveness of planar metallic meshes with measurements in cascaded reverberation chambers. Progress In Electromagnetics Research C 2012;31:123–135.