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Available online 20 July 2020

https://doi.org/10.1016/j.ejvs.2020.05.017
DOI of original article: https://doi.org/10.1016/j.ejvs.2020.02.023

Response to "Re Biomechanical Assessment Predicts Aneurysm Related Events in Patients with Abdominal Aortic Aneurysm"

We thank Miller *et al.* for their interest in our recent publication.[1] Indeed, it was always the intention to test the developed methods[2,3] in the MA^{3}RS Cohort,[4] with our analyses beginning in 2017.

In response to the three points raised: (1) magnetic resonance imaging is often used to measure aortic wall thickness, with good repeatability reported.[5–7] We found mean wall thickness measurements to differ by ± 12% between three users. This equates to a 6% difference in maximum principal stress and <5% difference in peak aneurysm biomechanical ratio (ABR). (2) Including residual stress into wall stress simulations typically reduces the magnitude of the maximum principal stress. Therefore, all cases would have lower wall stress and lower ABR. It is unlikely that this would change the conclusions of the paper. We finalised our methods and began the ABR computation before Miller *et al.* published their residual stress approach in 2018.[8] Furthermore, their publication does not state that the method is included in new releases of BioPARR. (3) One could argue that no model is truly "patient specific" as assumptions are almost always required. We followed the common use of the term "patient specific" in abdominal aortic aneurysm (AAA) studies whereby the aneurysm geometry (including wall thickness in our work) and pressure loading are patient specific. Also, the wall strength model uses geometric information (local ratio of diameter; local thickness of thrombus), gender, and family history,[9] all of which are unique to that patient, to generate the pointwise strength data. Interestingly, Miller *et al.* refer to their AAA simulations as "patient specific",[9,10] despite using only simplified uniform wall thickness AAA geometries and blood pressure loading, which are less patient specific data than those used in the models of Doyle *et al.*[1]

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Available online 20 July 2020

https://doi.org/10.1016/j.ejvs.2020.06.017
DOI of original articles: https://doi.org/10.1016/j.ejvs.2020.05.017
https://doi.org/10.1016/j.ejvs.2020.02.023

Re "The Elephant in the Operating Room"

I read the work by Massiot *et al.*[1] and the commentary by Gonçalves and Chakfé[2] with great interest. Technology has provided us with high resolution imaging equipment allowing us to perform demanding procedures at a fraction of the exposure of older devices. In most centres, low dose protocols and radiation safety training are already in place. However,

daily exposure to radiation should not be underestimated as its cumulative effects could take decades to be evaluated. Because of the poly-aetiological nature of some pathologies (e.g. neoplasms), it may be impossible to link final health effects of radiation on medical personnel to exposure sustained by those personnel many years previously.

During a procedure, there are three to six individuals in the room. Any radiation dose received is dependent on an individual's distance from the radiation source, but continuous work in high volume centres results in accumulated exposure. Some of these professionals might be of reproductive age. Is it ethically acceptable to irradiate a number of young individuals daily and repeatedly for treatment of patients who are usually older and burdened with significant comorbidities?

This is a question that will raise the eyebrows of colleagues ready to cite the Hippocratic Oath. Yet, the situation described is not similar to putting a medical professional's health in jeopardy under extraordinary circumstances, e.g. intensive care unit specialists fighting COVID-19 or trauma surgeons operating in a war zone. The systematic exposure of young professionals to a silent hazard like radiation is the daily working environment of thousands. What happens when these individuals get sick or give birth to children with catastrophic genetic disorders? What are the social and long term financial burdens? Further research is required to find answers to these questions.

If we wish to discuss the details of the "Elephant in the Operating Room", we must also discuss the ethics of working with "Elephants".

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Available online 9 October 2020

https://doi.org/10.1016/j.ejvs.2020.09.008
DOI of original article: https://doi.org/10.1016/j.ejvs.2020.09.007

Response to "Re The Elephant in the Operating Room"

We thank Dr Patelis for his thought provoking letter. The risk of working with radiation is evident but still largely uncertain. There is no "radiation free" option for most specialists, certainly not for residents who are young and require great exposure in a short period of time, but also for nurses and anaesthetists. In short, we are compelled to put ourselves in harm's way to do our job. With the endovascular revolution, our practice now takes place in a dangerous environment, a fact that must be acknowledged.

This is one big mammoth we can hardly control, let alone ignore.

One cannot rely solely on ethics for radiation safety, we should strive for stricter regulation to protect professionals. This entails substantial investment in safety and monitoring equipment, improved risk assessment, enforcement of risk reduction measures, and obligatory (re)certification in radiation management. Administrators and physicians who do not comply need to be liable. Scientific societies and other professional associations, political stakeholders, and scientific publications like that of Massiot *et al.*[1] all play a role.

This elephant is not leaving the room. We must learn to tame it.

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Available online 13 October 2020

https://doi.org/10.1016/j.ejvs.2020.09.007
DOI of original article: https://doi.org/10.1016/j.ejvs.2020.09.008

Ethics in Occupational Exposure Needs a Green New Deal

We would like to thank Dr Patelis for his relevant comments regarding the worrying issue of long term occupational exposure.[1] We definitely agree that it is the real question lying behind all the recent literature regarding radiation. By law in France, staff are supposed to be trained, monitored, and adequately equipped against radiation. This is the institution's responsibility. On an individual basis, every operator has the moral responsibility of justification and optimisation.