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The Quarterly Journal of Nuclear Medicine and Molecular Imaging 2021 September;65(3):187-9
DOI: 10.23736/S1824-4785.21.03388-4

EDITORIAL

IMAGE-GUIDED SURGERY: FROM CLASSICAL TECHNIQUES TO NOVEL ASPECTS AND APPROACHES

Image-guided surgery: from classical techniques to novel aspects and approaches

Tessa BUCKLE [1] *, Clare SCHILLING [2], Tobias MAURER [3], Sergi VIDAL-SICART [4, 5]

[1]Interventional Molecular Imaging Laboratory, Department of Radiology, Leiden University Medical Center, Leiden, the Netherlands; [2]Head and Neck Academic Center, Department of Head and Neck Surgery, University College Hospital, London, UK; [3]Department of Urology, Martini-Klinik Prostate Cancer Center, University Hospital Hamburg-Eppendorf, Hamburg, Germany; [4]Nuclear Medicine Department, Hospital Clínic Barcelona, Barcelona, Spain; [5]Institut d'Investigació Biomèdica August Pi I Sunyer (IDIBAPS), Barcelona, Spain

*Corresponding author: Tessa Buckle, Interventional Molecular Imaging Laboratory, Department of Radiology, Leiden University Medical Center, Leiden, the Netherlands. E-mail: t.buckle@lumc.nl

Classical image-guided applications are based on radioactive sources, ranging from radioactive seeds to detection of radiotracer deposits in either the tumor or sentinel nodes (SN). Thereby, image-guided applications have shown to be a proving ground for technological advances. Furthermore, the increasing surge of image-guided applications have strengthened the field *via* concomitant development and clinical availability of optimized treatment plans/delivery, novel (disease-specific) tracers and detection modalities. In the pursuit of diminishing procedural side effects and complications, many interventional (therapeutic and surgical) applications are currently moving towards a minimally-invasive setting.

This special issue of *The Quarterly Journal of Nuclear Medicine and Molecular Imaging* focusses on classical techniques and novel aspects and approaches in image-guided surgery. Herein Dickhoff *et al.* perfectly describe the transformation of the well-established therapeutic use of radioactive seeds in brachytherapy towards their use in radioguided surgical resection.[1] In the latter, radioguidance can be seen as a benchmark application. Berrens *et al.* provide an overview of the novelties in radioguided surgery in prostate cancer.[2] This is further intensified by Würnschimmel *et al.* who additionally provide a contemporary update on available tracers that spans from traditional radiotracers to hybrid and receptor-targeted tracers.[3] Where intraoperative radioguidance is historically achieved using a combination of SPECT tracers and gamma probes, Collamati *et al.* discuss the translational in-human application of beta probes in radioguided surgery and Cerenkov imaging.[4] These include developments over time from first Geiger-Müller tube (1949) to beta-probes that are small enough to be used in robotic procedures. Preoperative nuclear imaging not only provides the starting point for radioguidance but can also be exploited for navigation purposes that allow improved directional steering towards the lesion of interest. Boekestijn *et al.* describe a typical workflow for nuclear imaging-based computer-assisted navigation strategies to assist in interventional radiology and image-guided surgery from a technical perspective and discuss clinical applications based on their anatomical target.[5] And last but not least, de Vries *et al.* go beyond radioguidance by illuminating the possibilities of fluorescence-guidance for intraoperative visual identification of (preoperatively defined) lesions during surgery; these include an overview of the fluorescent and hybrid (or bimodal; radioactive and fluorescent) tracers that have been applied in the clinical setting, including possibilities for multicolor combinations.[6]

Many of the recent innovations find their initial application in prostate cancer, before being applied in other tumor types. Here SN biopsy procedures serve as the prime application wherein novel techniques and technologies are first assessed. This evolution is probably steered by the

number of available patients and the increased application of robotic (laparoscopic) devices in prostate surgery; together these aspects provide both the ability to include novel image-guidance techniques without large adaptation of the existing clinical workflow and the possibility of assessing the additional value of a novel technique in large patient cohorts. The latter seems to be highly important as, to date, techniques that have developed in addition to, and not replacement of, current image-guidance techniques have proved to allow a smoother translation towards routine clinical implementation. The two prime examples herein both elegantly combine chemical innovation/tracer development with radioguidance concepts previously validated during SN approaches. The first is based on the combined use of radio- and fluorescence-guidance in SN biopsy procedures, *via* the use of the hybrid tracer ICG-^{99m}Tc-nanocolloid.[7] The second is the recent introduction of ^{99m}Tc-PSMA targeted salvage surgery, as an extension of PSMA-based diagnostic PET imaging.[8]

While success stories like these motivate clinicians and researchers active within nuclear medicine and surgery to create technologies that meet the clinical demand, it is clear that several hurdles exist before clinical implementation can be achieved (ranging from regulatory issues that need to be mastered to definition of additional value of novel image-guidance technologies). Besides radioactive seed placement in brachytherapy[9, 10] and image-guided SN biopsy[11] in the head and neck area, the use of novel techniques as described in this issue still largely remain limited to the experimental setting, without widespread standard use in clinical care and/or adaptation of clinical guidelines. With the vast number of new techniques and modalities that are being developed and clinically evaluated, one might also ask how many can be applied side by side and where a particular novel technique would have the highest beneficial value. The latter should, of course, be determined in close collaboration with clinicians. Here the impact and relevance of such image guidance modalities may vary per indication or stage of the procedure.

It was only very recently that the first studies have been completed that evidently take the use of hybrid tracers (ICG-^{99m}Tc-nancolloid) from proof-of-principle towards assessment of the impact and additional value of fluorescence-imaging during SN approaches.[12-14] An applaudable example, that should set the bar for the many other available novel image-guidance approaches (tracers, devices and applications alike). Herein important is to pinpoint the features that determine or influence the additional value of a particular image-guidance approach or technique. Diagnostic value, oncological outcome (*e.g.*, improved survival, lower recurrence rate) and the possibility of reducing complication rates (*e.g.*, surgical side-effects such as lymphocele or nerve damage) seem the most logical to include, but also the most straightforward to quantitatively compare to the current clinical standard. Measures such as decreased surgical time and the ease of performing surgery are dependent on the skill and experience, but also on the personal preference of the operating surgeon and as such benefits are difficult to quantify. In contrast, a possible role of image-guidance techniques may lie in decreasing the learning curve for execution of a particular intervention. Obviously, specific thought should already be given to the investigation of the additional value of image-guidance techniques during the initial set-up of a study. This will allow us to always keep the ultimate goal of improving patient care in mind, while minimizing the creation of surgical gadgets just because we can. Ultimately, how well we will be able to evaluate and define the worth of the currently available image-guidance techniques, will determine their eventual widespread clinical implementation.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions.—All authors read and approved the final version of the manuscript.

History.—Article first published online: June 9, 2021. - Manuscript accepted: May 31, 2021. - Manuscript received: May 31, 2021.

(*Cite this article as:* Buckle T, Schilling C, Maurer T, Vidal-Sicart S. Image-guided surgery: from classical techniques to novel aspects and approaches. Q J Nucl Med Mol Imaging 2021;65:187-9. DOI: 10.23736/S1824-4785.21.03388-4)