



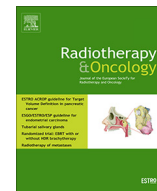
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Editorial

Radiation oncology in the new virtual and digital era

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COVID-19 hit the world starting at the end of 2019 and rapidly evolved into a full-blown pandemic early in 2020. In May 2020, *Radiotherapy & Oncology* established a special collection of rapid communications to meet the need for fast international information and exchange on COVID-19 indications and treatments at a time when scientific evidence was - and to some extent still is - lacking [1]. Nine months later, the world has fundamentally changed. As of November 2020, over 65 M confirmed COVID-19 cases and 1.5 M deaths worldwide have placed an unimaginable and unprecedented burden on our healthcare systems [2] and on our societies as a whole. Healthcare professionals have been working at their limits, and scientists around the world are seeking effective treatments and vaccines to control the infection chain. In parallel, the pandemic has vastly accelerated new digital and virtual reality mega trends and set in motion a dynamic that will have lasting effects and will change science and society both in a positive but also in a challenging way. These changes will also have profound effects on how the radiation oncology community provides patient care, educates and trains the next generation of professionals and performs, discusses and disseminates research results - including scientific publishing in journals such as *Radiotherapy & Oncology*.

Patient care/virtual care

Restrictions to movement and the need to minimize hospital attendances for patients have revolutionized our traditional means of working in the past six months. This has required the rapid adoption of new technological solutions, both in computer hard-

ware and software. Changes in hospital information technology (IT) processes, which have been pending for many years, appeared overnight. Remote access to hospital systems was suddenly readily available through virtual private network (VPN) connections, streamlining our ways of working and increasing efficiency.

Virtual patient care has received new impetus during the pandemic. Videocalls to patients or symptom tracking through apps have been established as very convenient tools to interact with patients, e.g. during follow-up or even under radiotherapy. However, these tools must have measures in place to secure patient data. In addition, tasks that require hands-on and therefore in-department presence and those that can be done remotely require robust communication between separate sub-teams and need to be clearly identified and interfaced. For clinical evaluation and decision-making across boundaries, standardized data recording, transfer and consistency is required to improve communication. However, there is also the danger of losing or weakening the sense of multi-disciplinary team community, missing out on informal "coffee conversations" and diluting the transfer of common information between groups and sub-groups in a department. To ensure these positive aspects are retained, also clear intra- and inter-team communication channels must be created and maintained. Whereas most patients may prefer a call and the use of apps to track symptoms in the comfort of their home to the trauma of hospital parking and often lengthy waiting times to be seen, there remains the risk of excluding patients with little or no internet experience or who do not own the equipment, e.g. elderly patients or those with lower education or low income. Many patients will also miss the personal interaction, and there is always the lurking fear that conditions may be missed without actually seeing and examining the patient.

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The radiotherapy (RT) workflow is a complex process consisting of several time-consuming steps that affect treatment quality and hence patient outcome. Artificial intelligence (AI) has been proposed as a tool to increase quality, standardization and acceleration of these steps, leading to a more safe and accurate radiation administration by automation and optimization of workflows. Especially with the introduction of adaptive radiotherapy (ART), a streamlined workflow is mandatory in clinical routine.

Over time, automation including AI, and its sub-domains of machine-learning and deep-learning, will undoubtedly facilitate the possibility of analyzing heterogeneous clusters of data to identify subgroups of patients separated by diagnostic and clinical characteristics, sensitivity to therapies and quality of life. At the same time interactive Internet of Things (IoT) and telemedicine devices will allow a longitudinal home-hospital integration allowing an effective AI based evaluation of therapies, including using patient reported outcome measures (PROMs) and experience measures (PREMs), and increasing personalized intervention. However, in this scenario data sharing and security will need to be carefully managed to ensure data protection (cloud, networks, platforms) and secure remote access to databases.

Overall, the pandemic has taught us that the virtual world has the potential to improve global healthcare by centralizing and sharing expertise. Many tasks in radiation oncology (and also in medicine in general) can be performed virtually, such as delineations and isodose planning, treatment decisions, and many more. Dispersed collaborative networks can provide the clinical information to a central hub so that experts (regional, national, international) could work together to decide the best treatment strategy and plan for the individual patient. They may be guided by deep neural networks built on huge central databases, leading to quality improvement, standardization and ultimately better patient outcomes.

Teaching/training/examination

Teaching, and to a significant extent also training, has rapidly moved on-line, mandating new training and education requirements. Due to large efforts of all involved, we are seeing the development of new lecture/seminar formats, e.g. interactive online courses, solving pre-defined tasks in digital workspaces and many others. Without the pandemic this switch to virtual formats would have taken several years to evolve.

Nevertheless, for teachers the experience of lecturing to a computer screen, which does not provide audience feedback and which hampers the ready interaction a live seminar or lecture may provoke, is daunting. Students, on the other side, will need to be more self-motivated – requiring skills which may have been concealed in the past decades in which more formal and school-like formats have replaced academic freedom to study apart from fixed curricula. Some will adapt quickly and use the opportunity of gained flexibility and learn faster, but others may fall behind leading to reduced participation and lower examination performance. In addition, limited personal contact may result in social isolation and the enhancement of specific psychological issues.

AI in oncology, imaging and radiotherapy will inevitably require some rethinking of training courses to prepare young people, as well as updating and preparing senior staff to make the best use of these new teaching technologies, while universities will need to reconsider the way obtained knowledge is being tested, e.g. via multiple choice questions, or completely novel assessment methods, to ensure the integrity of online exams. A major benefit is that student experience will be wider as new interactive lecture/seminar formats develop, allowing for more student-student interaction as well as self-led, flipped and blended learning. All

in all, digital teaching will have a much greater outreach, but it will never be able to replace personal contact completely.

Even with perfect virtual classroom approaches, practical training, particularly in all fields of medicine, remains a very critical issue. This calls for hybrid solutions with an integration of safe formats for gaining or further developing practical skills and physical classroom experience with state-of-the-art virtual modules. Such broadened as well as deepened hybrid curricula would offer real added value to students and teaching staff and lead to lots of good arguments to continue and further develop them even after the current pandemic has come to a halt.

COVID-19 had a significant impact on the activities of the ESTRO School in 2020. 40 live courses were planned in or outside Europe, but when the pandemic crisis began, only two of these had actually taken place. The ESTRO School had to quickly adapt to the new Corona situation by switching to a virtual learning platform. It was clear that this would not be the same as the live courses, losing live interaction between participants and teachers, but it was felt that this could be a realistic alternative, as the online media could provide other advantages and benefits. Course faculties were given a certain amount of freedom to design their courses in a way they felt most appropriate. This resulted in six courses with six very different approaches to the usage of online media and which was met with great interest from the community. To date, 838 participants have registered for the online events, and with the FALCON workshops, ESTRO 2020 pre-meeting courses and the two live events, the ESTRO School achieved close to 50% of the attendance in a regular year. Most importantly, the online events were very positively evaluated by the participants. The experience gained so far will be valuable for creating new online courses in 2021 and beyond.

Communication/conferencing/meetings

The virtual world makes it possible to work remotely, including from home, and young researchers from all over the world to meet virtually on a regular and more frequent basis to discuss and exchange research findings. Traditional conferences may also become less frequent events, while blended conferences become state-of-the-art.

To turn this into a sustainable model, stable broadband connections and behavioral guidelines are needed to avoid attendees suddenly “disappearing” or virtual conferencing (VC) being hampered by, e.g. the ‘legacy hand’, which is never switched off. Personal interaction and “coffee conversations” that often solved problems in ways that were not possible in a formal meeting, and informal discussions that generated new ideas and contacts would be no longer possible, at least not with current VC systems. While travel to a venue away from the workplace enabled greater concentration on the presentations, screen fatigue can set in after serial presentations. However, this can be countered by looking at the presentations more than once. Considerable discipline is also required to log on and stay with it when it is known that you are “available” for clinical work. Similar dangers to those identified above for department teams will also affect wider professional teams, e.g. the sense of multi-disciplinary team community and the transfer of common information between groups.

One important opportunity is that getting used to video conferencing makes it easier to quickly connect with colleagues all over the world and discuss scientific views, progress of research and initiation of grant proposals and collaborations on a regular basis. The virtual world not only enables more frequent meetings, it is also less expensive and has a lower barrier for young researchers to join. Group leaders can also easily join, thus stimulating their thinking and guiding them as needed. In this way, worldwide com-

munities can be set-up with strict criteria on when guests or students can join (e.g. by invitation only, or more open situations). This does not exclude traditional conferences but if these become less frequent they may also be less crowded and more focused. Young researchers will become much more selective in choosing the meetings they want to attend in person rather than virtually as they get to know the key opinion leaders from the virtual communities they participate in. This makes it easier for them to identify who they would like to meet in-person for discussion. However, especially for new initiatives there is also a considerable risk of remaining within one's inner circle.

The ESTRO 2020 meeting, which was planned to be a major celebration of the Society's 40th anniversary [3], ended up as a virtual congress. The set-up and the quality of the presentations on the online platform were impressive, and based on the given conditions, one can only admirably concede that ESTRO managed the meeting very successfully.

Overall, virtual (or even blended) conferences offer many exciting opportunities for the future. For the first time the much lower costs involved in attending a virtual meeting make it possible that much larger numbers may attend the meetings they always wanted to go to, including participants from less affluent countries and regions. Virtual meetings also save time which in the past was taken up for travel and can be balanced more flexibly with the tasks at the home department. Traditionally many of us attending a conference also ended up in some sessions out of their field of expertise, which broadened our perspectives. This invigorating experience can be further enhanced as it is possible to visit more sessions in a virtual conference than at a physical meeting. However, a lot of personal networking, including intense mentoring of younger colleagues could take place in the conference center as well as during dinner and social events. The multiple interactions and connections, the discussions of new ideas and planning of collaborations or simply keeping track of the well-being and careers of colleagues etc. are missing. Chats or emails on the side do not compensate for that.

Congresses and meetings support the establishment and growth of collaborations and the then good work based on networks of people who know each other. This becomes problematic if there are only virtual conferences and meetings, since this can encourage conservatism and the continuation only of existing collaborations, while the opportunities for lesser known (young) people to enter the scene are more difficult, as these opportunities arise from all the collateral activities that take place at a large meeting. Thus, such meetings may work for a short time, but can be hazardous when it comes to ensuring the continuous development and mentorship of the "young bright ones".

It is yet unclear whether the lack of these secondary functions of meetings will weaken professional communities – but there is plenty of reason to watch this carefully. The editors writing this paper believe that physical meetings will rapidly re-emerge after the pandemic. Nevertheless, components of what has been established in virtual meetings, most importantly accessibility to a broader community, should certainly be kept, so we expect that there will be blended meetings or combinations of physical and virtual meetings.

Research

In a recent review article, speculation was presented on how radiation oncology may look like in 30 years [4]. Automation and digitalization will lead to higher precision medical diagnosis and treatments and the radiation oncology field will become more multidisciplinary with data scientists and others working alongside clinicians, medical physicists, RTTs and radiobiologists. At

the same time, cancer prevention and early detection will hopefully lead to a smaller proportion of all patients requiring treatment. This may significantly contribute to improved global access to health care resources in radiotherapy. The recent *Radiotherapy & Oncology* Special Physics Issue 2020 provides an overview and examples of how automation will advance physics scientific developments and thereby impact on clinical practice in cancer treatment [5].

In science the foundations of knowledge are built on data collected on a sound basis. This also means that the evidence-based clinical guidelines we use derive from such data. Experimental science follows the rule that you think first, formulate a hypothesis and then design an experiment to address it. In the medical clinical context, this is usually a prospective study. *Radiotherapy & Oncology* therefore strongly advocates the publication of prospective information. In the course of the previous year we have continued to give priority to the publication of evidence-based guidelines, which have gained importance during the pandemic for assessing COVID-19 information, as well as to underlying systematic reviews and meta-analyses, and controlled clinical trials. This prioritization has increased over the years, and we will continue to emphasize the importance of such a practice [6]. This also means that data obtained through the use of evidence-based guidelines should be prospectively recorded in databases (preferably population-based), and the results subsequently reported in phase 4 studies, so that the guidelines can be continuously adapted.

Nevertheless, much of our current knowledge relies on retrospective data, and *Radiotherapy & Oncology* will continue to publish high quality retrospective studies and, at the same time, to advance the knowledge on the appropriate use of data-science methodology for analysis [7]. In contrast to prospective studies, retrospectively collected data have usually been accumulated without pre-planned structure or knowledge. Therefore, retrospective studies have well recognized limitations. These limitations to a large extent also are relevant when it comes to incorporating retrospective clinical data into models. Thus, uncritical use of digitalization in radiation oncology may run some risk of generating models without challenging the results with specific studies addressing the question. However, taking the general principles of science and the specific caveats inherent to retrospective data into account, computer-based activities in radiation oncology bear significant potential to support the evaluation of clinical, imaging and biology data, e.g. in TCP and NCTP modeling, in image segmentation, radiomics and bioinformatics [8,9]. Advancing these digital technologies usually needs large data sets and therefore profits from usage of data which were sampled in the past. Data modeling can play an important supporting role in evidence generation and can provide information that can help to generate questions for future prospective trials. This also puts focus on ensuring data collection going forward is detailed, consistent and of high quality and that models are adequately tested and validated.

Social media and peer review

During the COVID-19 pandemic *Radiotherapy & Oncology* has received well over 30% more submissions than in prior years. This has created an extra burden for our editors and reviewers, who have had to adjust their time to meet the increased demands of a struggling healthcare system as well as cope with tight timelines for peer review associated with professional scientific publishing.

Alternative models of publishing are frequently discussed now in social media, among editors and publishers of traditional journals but also among funders and political decision makers. Among the ideas proposed are cloud reviewing, and cloud or social-media posting of research papers. These ideas are interesting as they are

cost effective and rapid, and are considered more democratic by many. However, the quality of cloud reviewing as an alternative to normal peer review may be hampered by the members participating in a cloud review not always being experts on the topic. They may have become a member simply because they are interested in the topic/s and because they have time, as they may not be already involved in more formal peer review processes. Comments from cloud reviewers may be poorly validated or represent over-simplified opinions, which eventually will not accelerate or enhance the publication process. It should not be underestimated that the quality of any disseminated science is dependent on the comments of specialists in the particular field. Also, publication without peer review has many limitations, and, as not everybody can be an expert for everything, such publication can bear significant risk of parallelism of opinions not substantiated by data with rigorously quality-assured scientific evidence. There has been clear recent experience of the potential damage this may cause in discussions on whether SARS-CoV-2 exists at all, the risk of infecting others, or the usefulness of masks during the current pandemic.

Posting links on social media to properly peer-reviewed research papers when published and enabling discussion of such papers is potentially a more effective way of allowing people to comment on your work and 'post-publication' review and discuss it openly. In particular, professional social media sites, i.e. LinkedIn and Twitter can be very useful in disseminating new publications and knowledge. However, it takes time and effort to update all the social media and follow the comments that people provide.

Outlook

From a radiation oncology perspective – whether for a clinician, medical physicist, RTT, nurse, data-scientist or radiobiologist – we expect that the new digital technologies which were implemented rapidly in the past year will be disruptive on the one hand, but on the other hand also give rise to a wave of new opportunities and challenges. Many traditional tasks will become automated in a world where the radiation oncology team will be involved in implementing, validating and ensuring performance and effectiveness of these new systems in all areas of healthcare, including telemedicine, training and education of healthcare professionals, research and new knowledge dissemination. However, there will be a need for standardization and of critical assessment of these innovative technologies at sustainable costs if global health is to benefit.

Digital communication lacks direct social interaction, which can make it difficult to build efficient collaborations, as these are often based on expertise, information and mutual trust acquired in real-

life meetings. However, once a collaborative project is ongoing the rapid exchange of data and joint analysis will be greatly facilitated in the digital era. As above, we have pointed out the dangers of losing or weakening the sense of multi-disciplinary team community and the transfer of common information between groups and sub-groups at various levels. To ensure such team protection, visibility and identity, as well as providing information that can begin to generate questions for future prospective trials, clear unambiguous communication is necessary to be established and maintained and an appropriate culture must be created.

Social media connectivity will facilitate the development of value capture and co-creation opportunities only if participatory validation systems are available. The persuasive power of communication technologies and the development of patient info-sharing communities make it necessary to know and use social media technologies to monitor the quality of information circulating. It is necessary to have dedicated staff for this purpose for the different disciplines and to deal with training and education on these issues.

Radiotherapy is a specialty that has historically evolved by taking advantage of technology. The pandemic has changed our world by accelerating the speed of digital transformation processes. We need to seize this opportunity and change with it!

The Editors

Conflict of interest

All the authors have approved the final version. There is no conflict of interest in connection with this work and the material described is not under publication or consideration for publication elsewhere.

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