OPINION

The need for multidisciplinarity in specialist training to optimise future patient care

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Abstract |

Harmonious interactions between radiation, medical, interventional and surgical oncologists, as well as other members of multidisciplinary teams, are essential for the optimisation of patient care in oncology. This motivation is particularly important in the current landscape, in which standard-of-care approaches to cancer treatment are evolving towards highly targeted treatments, precise image guidance and personalised cancer therapy. Herein, we highlight the importance of multidisciplinarity and interdisciplinarity at all levels of clinical oncology training. Potential deficits in the current career development paths and suggested strategies to broaden clinical training and research are presented, with specific emphasis on the merits of trainee involvement in functional multidisciplinary teams. Finally, the importance of training in multidisciplinary research is discussed, with the expectation that this awareness will yield the most fertile ground for future discoveries. Our key message is for cancer professionals to assume their duty in ensuring that trainees appreciate the importance of multidisciplinary research and practice.

Communication across different specialties remains a core element of cancer care. Communication skills are important in establishing a good relationship with patients, but in the increasingly complex field of cancer treatment, oncologists from each specialty need to be equally skilled at communicating with, and learning the art of, those focused on other specialties. One current view is that four 'pillars' exist in oncology: radiation oncology, medical oncology, interventional oncology and surgical oncology, with some degree of interdependence between all four disciplines (FIG. 1). Nearly all patients will come into contact with clinicians practising one or more of these specialties during their cancer care continuum. To achieve the best outcomes for patients, expertise relating to these four pillars needs to be integrated and combined wisely, and all treatment options need to be considered to provide an optimal care pathway for each patient. This approach should also drive innovation and efficient use of health-care resources across populations.

The length and scope of oncology training varies between health-care systems, but typically specialization in radiation and medical oncology requires 4–5 years of clinical training to obtain accreditation from a national regulating body, such as the Royal College of Radiologists (RCR) in the UK, or the American Board of Internal Medicine (ABIM) in the USA. Surgical oncology and interventional oncology training can vary between 4-8 years. These timescales for clinical training do not include time taken out of specialist training to experience research or undertake an higher degree. Trainees usually follow a systems-based or organ-based syllabus to study different tumour sites and practical procedures (particularly in the specialties of radiation, surgical and interventional oncology). The proportion of oncology trainees undertaking full-time research varies widely between countries and regions. This research can be either laboratory-based or clinical, and can lead to the award of a higher research degree or in securing medium-term placements to learn specific skills, such as stereotactic radiotherapy or radiofrequency ablation (FIG. 2).

Similarly to the patterns observed for many medical specialties, the proportion of female trainees and specialists in oncology has increased over the years. The ASCO State of Cancer Care in America report notes that the proportion of females in all oncology specialties continues to rise, and in 2015, 46% of trainees in oncology fellowship programmes were female[1]. In the UK, the RCR 2014 workforce census recorded that 65% of clinical oncology trainees were female, compared with 46% of consultants at that time[2]. Of note, 25% of consultants included in the census worked less than full-time, with this figure rising to 40% for female consultants. As well as having implications for workforce planning, this disparity highlights the need to ensure training, academic work and family circumstances are balanced to enable each individual to achieve a work–life balance that maximises satisfaction and productivity, while meeting the patients' care needs. General surgery is attracting a growing proportion of female trainees around the world, although they remain in the minority compared to male surgical trainees; this gender gap is even more pronounced for non-white female trainees[3]. In the UK, the proportion of female surgical trainees increased from 15% in 2009 [4] to 28% in 2013 [5].

Cancer services are encountering significant challenges in the current health-care climate, which relate to rapid advances in the development of novel therapies, escalating costs of interventions and ageing populations[6]. Current financial constraints limit access to cancer therapies, and shortfalls in the required numbers of trained oncologists are expected in several countries owing to poor workforce planning [7]. In order to achieve the best possible care for all patients, the current deficits in the training of cancer specialists must be recognized, and strategies for optimized multidisciplinary training must be defined.

[H1] Clinical training

Clinical training should provide oncologists with a standard toolkit with which to approach the care of all patients with cancer and the toolkit should be tailored to each discipline's common and local practice. Data-driven clinical trials should be a driving force for progress in clinical oncology; training in regulatory and clinical trial science and administration will facilitate the incorporation of clinical trials into oncology care in the future. Academic translational efforts in conducting phase I–III oncology drug trials should be combined with innovations in medical devices, and an increasing proportion of clinical trials should be focused on a rational methodology for combining drugs, devices, radiotherapy and imaging guidance for local therapy. An example is the phase I-III clinical trial advancement of yttrium-90 microspheres combined with chemotherapy, achieved by radiation oncologists, medical oncologists and interventional oncologists working collaboratively [8, 9]. Such demonstrations of academic multidiscplinarity in practice send a clear message to trainees on how collaboration can strengthen research and clinical practice.

The current reality is that clinical research is often conducted within independent silos of research and clinical conferences, with different specialties having varying levels of appreciation of emerging therapies in other disciplines. A basic understanding of clinical and translational research should be mandated by all training programmes — for example, as part of the 'core competencies' governed by the Accreditation Council for Graduate Medical Education (ACGME) in the USA[10]. By making this aspect of training mandatory, more oncologists will become familiar with the ethics and regulatory science of clinical trials.

Several professional organizations have a multidisciplinary teaching role (BOX 1). These initiatives are breaking new ground by developing cross-speciality courses but further developments are required. Most innovation in cancer care continues to originate from specialist organizations, such as the European Organisation for Research and Treatment of Cancer or the Radiation Therapy Oncology Group, which generally remain predominantly oncology-focused and specialty-specific. Because innovation in academia has run along speciality-specific tracks, innovation in industry has tended to proceed in parallel rather than in synergy and hence academic training, siloed from commercial partners, has generally not benefitted from the expertise of industry. Improvements in cross-specialty integration with industry partners could potentially offer the ability to steer innovation and development of new products, and to better integrate them into multidisciplinary care pathways.

[H2] Radiation oncology

Radiation oncology is a specialty focused on the assessment of patients receiving radiotherapy, and the technical design, delivery and overall optimization of these therapeutic approaches. In the UK and other countries, many oncologists are dually trained in radiation and medical oncology, in a discipline termed 'clinical oncology'. Specialization in radiation or clinical oncology in the UK, USA, Australia and New Zealand typically requires 5 years of training designed to impart knowledge of the physics, anatomical and pharmacological aspects integral to these disciplines. Proficiency in these areas is tested with formal examinations, such as those conducted by the RCR in the UK and the RANZR in Australia and New Zealand. Research is not mandatory in most training schemes, but is increasingly encouraged to foster a better understanding of the changing therapeutic landscape in oncology.

In all countries, radiation oncology trainees benefit from a multidisciplinary approach involving close liaison with radiographers and radiation therapists (allied health professionals who deliver the radiotherapy), and physicists and dosimetrists (who plan the technical aspects of treatment). Radiation oncology trainees are increasingly required to receive advanced training in radiology, however, because current treatments are commonly guided by daily imaging scans. The most frequently used imaging modality is CT, but magnetic resonance (MR)-based approaches are also being developed[11]. In the absence of radiation oncologist with the necessary training in advanced radiology skills, including those relating to novel imaging techniques[12, 13], the recurrence rates of patients with cancer might increase, owing to inadequate tumour delineation or 'geographical misses'. The faculty at Duke University Medical Centre have therefore designed a specialist radiology training programme for its radiation oncology residents[14]. This type of training is currently an unmet need in many oncology subspecialties: in the 2013 Annual Survey of UK Clinical Oncology trainees, only 2.6% reported they had received formal radiology training from a radiologist, and 35% had 'self-taught' the radiology skills they needed in clinical practice[15]. Faculty in charge of future training of radiation oncologists should identify potential synergies with radiology teaching schemes, in order to improve the training in both specialties.

Trainees in radiation oncology also need to learn how to respect and work with interventional radiologists and medical oncologists. New paradigms in radiation treatment, such as the radical treatment of oligometastases with stereotactic body radiotherapy[16, 17], require close integration between oncologists from a range of disciplines who also have the ability to deliver ablative treatments, to ensure that the patient receives the most-appropriate treatment. For example, radiofrequency ablation[18], which can be delivered by interventional or surgical oncologists, is an alternative to stereotactic body radiotherapy for some patients. Thus, all oncologists need to develop a good understanding of alternative ablative treatments (such as microwave, laser, cryoablation, or focused ultrasonography for thermal ablation) in order to optimize care for patients. Likewise, combinations of targeted agents (such as sunitinib) and radiotherapy might result in improvements in cancer control. Hence, close collaboration between radiation oncologists and medical oncologists is required to maximise benefits of radiotherapy combinations with other therapeutic modalities, and to minimize the risk of adverse events associated with treatment modalities that might potentiate radiotherapy toxicity [19].

[H3] Research within clinical training programmes.

Access to full-time research fellowships during training is limited and highly competitive. In most health-care systems, dedicated research time is not contemplated as a priority in training programmes. Indeed, data from a small survey indicate that trainees who do not conduct full-time research publish an average of less than one peer-reviewed article prior to becoming a consultant [20] supporting our belief that for academic outputs to flourish, dedicated research time within training is required. Since 2005, trainees in radiation oncology in Australia and New Zealand have been mandated to complete at least one piece of independent research of 'publishable quality' as part of their training, although this requirement is not supported by allocation of protected research time. A survey of 116 trainees in these countries published in 2014 revealed that 53% had published research in a peer-reviewed journal, and 59% had presented their work at an international meeting[21]. For some of these trainees, the encouragement to conduct academic work could foster career-long enthusiasm for research; thus, the effectiveness of other training schemes might be improved using this approach.

In order to pursue high-quality research, however, individuals need dedicated research time, both during training and after certification as a specialist. For future oncologists to run practice-changing trials, research training needs to be met. In the USA, the need for a formal clinical trial training programme has been identified in response to data showing that many trainees lack confidence in clinical trial design[22]. In the UK, the Academic Clinical Fellow (ACF) radiation oncology training programme incorporates dedicated time for research, enabling trainees to spend time in the laboratory or on a full-time clinical research project[23]. In the Netherlands, all trainees spend at least 10% of their residency time engaged in full-time research, and many have completed a PhD in a related discipline before starting their radiation oncology training.

[H2] Medical oncology

When the ESMO was first established in 1975, its founders defined seven core principles[24] (BOX 2), many of which focused on the importance of multidisciplinary care. These principles should remain a driving force in medical oncology training, because they reflect the current key areas of training: clinical and translational research, acquisition of clinical skills, and the ability to establish effective and fit-for-purpose clinical and research networks.

[H3] Clinical training programmes.

Medical students considering a career in medical oncology often gain only limited experience in this discipline at medical school. In Europe, both ESMO and the European School of Oncology (ESO) have recognized this problem and currently run a joint 5-day residential course that is available to medical students who wish to gain more insight into medical oncology [25]. By offering this intensive educational programme, ESMO and ESO aim to motivate medical students to commit to working for the benefit of patients with cancer in the fast-evolving field of medical oncology.

In most countries, including the UK, training of medical oncologists is structured as a 4-year specialist programme, with trainees rotating through supervised posts, in which they are involved in caring for patients with common tumour types (such as gastrointestinal, breast or lung cancers), to cover the core syllabus set out by the training boards. The introduction of postgraduate structured exams by the UK Royal College of Physicians (RCP), ESMO and the ABIM has enabled the core syllabi to gain international recognition, and guarantees that accredited medical trainees obtain harmonized clinical knowledge before completing their training.

The future needs of medical services are difficult to predict, but undoubtedly the demands on cancer services as a whole will increase as a result of the ageing population demographics worldwide. This demographic trend will also necessitate broader understanding of the additional challenges relating to cancer care specifically in the elderly population. Joint training programmes in geriatrics and oncology do exist worldwide, but remain limited. The need for such training was first identified in the USA in the 1990s[26], and the introduction of similar programmes in some European countries, e.g. France, followed shortly after [27, 28]. Both ASCO [29] and ESMO [30]have now published specific guidelines on cancer therapies for the elderly, an international society has been established [31] and pilot schemes exist to address the unmet training needs related to this previously under-represented area. Certain countries, including the UK, may have fallen behind by taking a less proactive approaches than those adopted in the USA and European countries (among others)[32] and this could be addressed by including tools for geriatric assessment in all training schemes[33].

Although not considered traditional pillars of cancer care, clinical genetics, immunology and molecular pathology are specialties that have become critical to delivering patient-centric cancer care. Over the past decade, the proliferation of tissue-based and blood-based biomarkers of prognosis or response to treatment has increased dramatically for example in lung cancer [34]. Patient stratification on the basis of mutations in cancer-related genes is now a reality in clinical trials, and molecular criteria determine patient access to treatments outside clinical trials. The expanding use of immunotherapies, particularly immune-checkpoint inhibitors, in clinical practice means that knowledge of immunology is becoming increasingly important for all oncologists to evaluate the full range of treatment options available and to manage the adverse events associated with immunotherapies [35, 36].

Another important discipline for which training varies widely between countries is palliative care. In many respects, training in palliative care gives oncologists a broader perspective on patient care than any of the other disciplines because they have to learn about managing pain and other symptoms, as well as the importance of considering the patient's physical, psychosocial and spiritual wellbeing. Palliative care is delivered in a variety of settings, including hospices, hospitals and the community, which creates challenges in training oncologists adequately in this discipline. Despite this potential barrier, the management of symptoms in patients with cancer is acknowledged as a key aspect of training; thus, the Joint RCP Training Board in the UK has prioritized training in palliative care within the medical oncology curriculum [37].

[H3] Improving trainee access to clinical and translational research.

Traditionally, medical oncologists have tended to have more opportunities to perform clinical and translational research than other oncologists, and approximately 75% of medical oncology trainees will undertake a higher research degree [38]. In the current worldwide financial climate, however, securing funding for such endeavours has become increasingly challenging for clinicians. In the UK, most funding for junior clinical fellowships comes from cancer charities, such as Cancer Research UK (CRUK), or large medical research charities, such as the Medical Research Council and Wellcome Trust. In the USA, early career clinicians are eligible for prestigious government-sponsored funding opportunities, such as the NIH Mentored Clinical Scientist Research Career Development Award (K08) [39], Early Investigator Award, and Patient-Oriented Research Career Development Award (K23) [40], which allow clinicians to dedicate a 3–5 year period of their career to intense, supervised research as a pathway to autonomy, and with the ultimate aim of educating a future generation of NIH researchers.

The competition for obtaining these early career grants is fierce and, somewhat paradoxically, previous experience in laboratory research considerably improves the prospects of successful application. Without funding, trainees often cannot leave clinical training positions to gain experience in the laboratory. As mentioned previously, the UK ACF programme (FIG. 3) might better prepare trainees for the competitive world of academic medicine, and should, therefore, be made available to an increased number of trainees.

Clinical research is a valuable component of training that, unfortunately, is often incorporated *ad hoc* into clinical training programmes. Few trainees have the opportunity to work in large early clinical trials units, but such experience is an important aspect of the professional development of future oncologists. Access to local research networks and first-hand experience in trials units will facilitate oncologists in referral of well-selected patients for enrolment in clinical trials. If fellowships in such units are not possible, trainees should have access to local research networks, and the opportunity to participate in multidisciplinary forums for local research, such as a the pan-UK Cancer Research Network [41].

[H2] Interventional oncology

Despite health-care system deficiencies, vascular and interventional radiology (VIR) with specific application to cancer care have fostered the subspecialty of interventional radiology with specific application to cancer care, which overlaps substantially and synergizes with the other three pillars of oncology. Previously, these types of interventional procedures were mainly associated with symptomatic control and palliative or supportive care but, at present, interventional oncology is increasingly used with the goals of increasing patient survival and/or cure rates of certain cancers[42], such as liver cancer or renal cell carcinoma [43], which can be achieved using cryoablation or thermal ablation with radiofrequency, microwave, or laser electromagnetic radiation. Interventional oncology has become a vibrant and dynamic component of most interventional radiology practices, aimed at standardizing the use of multidisciplinary personalized therapies.

The Society of Interventional Radiology (SIR) in the USA [44], and the Cardiovascular and Interventional Radiology Society of Europe [45] have promoted adoption and harmonization of clinical practice guidelines and reporting standards, and organized training symposiums and workshops to discuss paradigms in interventional oncology. In addition, education and cross-disciplinary training in minimally invasive, image-guided, locally and regionally delivered cancer therapies has been the main goal of numerous large meetings and multidisciplinary conferences, such as the World Conference on Interventional Oncology [46], European Conference on Interventional Oncology [47], Synergy [48], Symposium on Clinical Interventional Oncology [49], and Interventional Oncology Sans Frontieres [50]. These meetings promote multidisciplinary attendance by often offering free or discounted registration to partners from the host institution.

The three other oncology subspecialities are increasingly recognising the importance of interventional oncology. The RCR Sub-Faculty Board, for example, have stated that such training should be included in the clinical oncology curricula[51]. New techniques, such as selective internal radiotherapy treatment, require the skills of both oncologists and interventional radiologists for optimal patient selection, treatment and follow-up assessment[52]. Acquiring such skills can be difficult because a limited number of centres offer these services, and not every oncologist needs to be proficient in the techniques themselves. Nevertheless, a familiarity with interventional techniques will enable the appropriate selection of patients from all centres, thus improving access to these pioneering techniques.

Postgraduate training needs to evolve constantly in order to adapt to rapidly changing treatment paradigms. In previous decades, minimally invasive, image-guided therapies (for example, ablation and chemoembolization) have been increasingly integrated into the treatment algorithms for many cancers, with prominent roles for these modalities promulgated in National Comprehensive Cancer Network guidelines and various treatment algorithms for neoplasms of the liver, kidney, bone, and lung. These locally and regionally delivered interventional oncology therapies are most-commonly administered by physicians trained in VIR or interventional body imaging (a specialty within diagnostic radiology), who often lack formal independent dedicated or structured training in interventional oncology. The interventional radiology fellowship has traditionally been a 1-year fellowship after radiology residency; however, this short-term fellowship alone is clearly not sufficient to learn the requisite clinical and technical skills, owing to the rapid expansion of this specialty with enormous technological and scientific advances in areas including interventional oncology[53].Traditionally, VIR specialists receive fellowship training encompassing interventional oncology after a diagnostic radiology residency, but the extent of the oncology training experience widely varies across VIR fellowships. In 2013, the US ACGME approved an independent residency pathway for VIR training and primary certification [54]. Future US trainees will be able to receive VIR and/or interventional oncology training via a fellowship, or through an integrated or independent VIR residency pathway. Thus, medical students can enter VIR residency directly, or VIR fellowship or residency after completing a diagnostic radiology residency (6–7 years of postgraduate training). The 'Residents, Fellows and Student' section of the SIR promotes training opportunities in interventional oncology at multiple levels [55], and the Medical Student Council of the SIR serves future students interested in interventional oncology within interventional radiology [25].

In addition, US clinical office-based care reimbursement coding for interventional radiology physicians increased 1,200% between 1998–2008[56]. In the USA, interventional radiology is transitioning to an independent residency status, which will result in improved procedural and clinical training of interventional radiologists, without affecting the number of post-graduate years they spend in training (total 6–7 years). This transition will also enable medical students to enter directly into the interventional radiology specialty through multiple pathways. The most important aspect of this transition will be the increase in clinical training, because interventional radiology trainees will perform rotations with their surgical and medical colleagues in oncology and intensive care, among other subspecialties. Nevertheless, imaging, procedures, and nonprocedural clinical care remain the three basic facets of the interventional radiology training pathway[56].

Interventional radiology has never been a more popular specialty among medical trainees than it is today. Between 2009–2013, the uptake of available fellowship positions increased from 54% to >90% in the USA[57]. Unfortunately, interventional radiology is not one of the six basic clinical rotations that all medical students must undertake in US medical schools, and only up to 25% of schools require a rotation in diagnostic radiology[58]. Surveys conducted with medical students indicate that <1% of them require conduction of a VIR rotation. The results of studies performed in the USA, European countries and Canada have demonstrated a general lack of knowledge of interventional radiology among medical students[57]. As interventional oncology becomes a larger discipline within interventional radiology, the exposure of students earlier in their careers to the existence and uniqueness of multidisciplinary interventional oncology is critical for this emerging discipline to assume a role in multidisciplinary team training. With the designation of specialty status for VIR by the American Board of Medical Specialties in the USA [54] and the recognition of VIR as an emerging subspecialty of radiology in the UK[42], further integration of interventional oncology into multidisciplinary care will maintain and even increase the strength of the fourth and newest pillar of cancer care.

[H2] Surgical oncology

One of the demands for contemporary training in surgery is to produce fully qualified surgeons who are aware of the particular needs associated with clinical oncology and who are capable of working functionally within complex multidisciplinary teams. The expertise of surgeons should include a blend of technical ability (with subspecialty skills), knowledge of oncology treatments, and the capability of enrolling patients into randomized clinical trials in high volumes. For example, three-quarters of the 41,000 newly diagnosed patients with colorectal cancers each year in the UK undergo surgical treatment for their cancer, but <10% of these enrol in a clinical trial[59]. Poor trial enrolment rates illustrate the need to formally improve provision and awareness of research within current surgical training programmes.

[H3] Technical skills in surgical oncology. Surgical oncologists are trained to a high standard in the prevention, diagnosis, treatment and rehabilitation of patients with cancer. These principles are championed by two pan-specialty umbrella organizations, the Society of Surgical Oncology in North America and the British Association of Surgical Oncology in the UK. Trainee-led groups exist within these organizations, including the Surgical Oncological Trainee Association [60] which promotes the needs and oncology-focused education of future surgeons.

Specialty-specific oncology training programmes are integrated into current surgical training, which are supplemented by fellowships bridging the gap between senior trainees and established consultants[61]. Fellowships on laparoscopic surgery are provided for senior trainees with gynaecological, urological and colorectal expertise; these fellowships have international scope (for example, the European Society of Coloproctology (ESCP) offers pan-European colorectal fellowships). Similar high-quality training fellowships are available across all surgical oncology subspecialties, on aspects including oncoplastic breast surgery, international travelling fellowships for gastroesophageal resection, minimally invasive urological training and ocular oncology.

Surgical training needs to keep pace with the rapid evolution of new technologies and multidisciplinary team working. For example, the British Association of Plastic and Reconstructive and Aesthetic Surgeons endorse courses in sentinel-lymph-node biopsy in patients with malignant melanoma, and simulator models have been developed for teaching sentinel-node biopsy in patients with breast cancer. Similar courses are delivered by the Cleveland Clinic and other large cancer institutions in the USA. Robotic surgery for urological, neurosurgical, neck, gynaecological and colorectal cancer is evolving, and robotic training courses and fellowships are already available. Current challenges in robotic surgery include the achievement of cost-effectiveness and real patient benefits. Assessment of the effects of these novel technologies on patient outcomes includes both registry-based commissioning and randomized clinical trials for new technologies[62], in concordance with the IDEAL Collaboration's recommendations for evaluation of surgical innovation[63]. Currently, a limited number of patients access such programmes and, therefore, deficits in the tutelage of trainees in the importance of clinical and economic benefit assessment must be addressed.

[H3] Translational research skills.

All surgical trials face recruitment challenges[62], illustrating the need to improve surgical oncology training not only in the UK, but also worldwide. Surgical training currently supports the development of skills required to conduct clinical trials among both dedicated academic and non-academic clinical trainees; hopefully, newly trained consultant surgeons emerging from these programmes will recruit patients into randomized trials as part of routine practice, with the aim that every patient undergoing surgery should be offered the opportunity to partake in a trial. Indeed, this skillset is starting to be incorporated into training programmes, with Good Clinical Practice certification [64] and the definition of milestones, such as a minimum number of recruited patients [65]. Trainee surgeons are supported within national cancer networks — for example, trainee members are part of the surgical subgroups of the UK National Cancer Research Institute. These members actively contribute to designing and conducting new trials. For example, the management groups of both the STAR-TREC and FOXTROT trials include surgical and oncological trainees who are shadowing their senior counterparts and are working together to contribute to funding applications[66].

In the UK, surgical trainees have pioneered trainee-led research collaboratives[67], which are regional and national networks of trainees connected by their annual rotations, and have been involved in planning and delivering multisite research[68], with numerous benefits (BOX 3). General surgical networks have complete national coverage and now encompass all surgical subspecialties [69]. These networks have the ability to deliver both multicentre observational and randomized research. For example, the randomized controlled ROSSINI trial[43] was conducted across 21 hospitals to test the efficacy of a wound guard in preventing infection of the surgical site after major abdominal surgery. As a national portfolio trial in the UK, this trial was designed and conducted by surgical trainees, who recruited 760 patients ahead of schedule[70]. The MAStectomy Decisions Audit (MASDA) study is an ongoing multicentre observational study that is being led by breast surgery trainees; the aim of this study is to describe the current UK practice in multidisciplinary team decision-making for patients undergoing mastectomy [71]. Trainee networks can also expand into Europe, as exemplified by the cohort studies delivered by the ESCP, in which trainees participate at each level.

Medical students represent the next generation of potential surgical researchers and, therefore, starting their collaborative and research training at an early stage would be advantageous. Such a strategy would immerse the prospective surgeons in the culture of multidisciplinary trials at an early stage of their careers, thereby facilitating the identification of future surgical oncology leaders. In the UK, a national network involving students interested in surgical research has been granted funding by the Bowel Disease Research Foundation to train 40 senior medical students per year in the practical recruitment of patients into randomized trials [72]. This initiative will deliver a research-ready cohort of junior doctors across multiple specialties, who will subsequently transition into regional surgical research collaborations[73].

[H1] Multidisciplinary working

[H2] The multidisciplinary team meeting

In many countries, multidisciplinary team meetings and tumour boards have become embedded into day-to-day clinical practice as a way of improving and standardizing treatment decision-making. In one international survey of practice in the care of patients with breast cancer, excluding those in the USA, 92% of respondents worked in a centre with a multidisciplinary team and, in over half of the 39 countries surveyed in Eastern and Western Europe, multidisciplinary-team-led decision-making was mandatory[74] and trainee attendance was encouraged. In these meetings, all newly diagnosed patients with cancer, and specifically the management plan for these patients, are typically discussed by teams comprising medical oncologists, radiation oncologists, surgical oncologists, radiologists, interventional radiologists, nuclear medicine physicians, histopathologists and, importantly, trainees in these disciplines. Representatives of all four pillars of oncology are present and, therefore, local standardization can be achieved whilst promoting a community-wide and culture-wide approach to treatment and instilling in trainees the importance of contributions from experts in other disciplines. Indeed, mutual respect and cross-disciplinary understanding of the different treatment options offered by each specialty should be incentivised and highly valued, facilitated by an exchange of data, ideas and new approaches to therapy.

Multidisciplinary teams can provide an important setting for multidisciplinary learning to take place, but no evidence exists on the extent to which trainees benefit from this learning opportunity, or whether dissemination of knowledge relating to various specialties occurs broadly and optimally among trainees. The financial costs associated with these meetings are high[75], but the meetings are credited with improving the outcomes of patients with cancer in the UK by reducing variations in clinical practice. Multidisciplinary team members believe that these meetings improve patient care and increase efficiency[76]. In addition, evidence supports the hypothesis that conducting such team meetings is associated with improved patient survival[77]. Involving patients in multidisciplinary team meetings has also been shown to be of benefit in terms of their quality of life[78]. Thus, the adoption of multidisciplinary teams can improve both the consistency and quality of patient care, and generate opportunities for multidisciplinary learning and exchange of knowledge.

[H2] Team working

Multidisciplinary team involvement is now an expected requisite in public health-funded research. Development of personal skills is a key feature in the training of capable professionals within the team; however, a shortfall in formal training of budding oncologists in communication skills is well-documented[79].

In addition, the high rate of 'burnout' amongst health-care professionals involved in the treatment of patients with cancer is recognized[80], and the constant development of new anticancer therapies requires a lifelong commitment to continued professional learning and development.

Multidisciplinary teams are at the heart of public–private partnerships, collaborations and think-tanks. Gone are the days when specialists in a single discipline (such as medical oncology) would develop a new drug without collaborating with other professionals. Funding bodies expect integration of combination therapies, medical devices, radiotherapy and systemic therapy in order to understand the context of the treatment being proposed[81].

Health-care systems globally must incorporate measures to reinforce mechanisms that reward multidisciplinary approaches to treating patients with cancer. In the era of precision medicine, the multispecialty approach can have numerous effects, from enabling patients to receive the most-appropriate treatment to delivering such treatments in a timely fashion. The best example of multidisciplinarity would be a combined specialty clinic in which patients would be jointly examined by professionals from two or more specialties[82]. Decreased time to diagnosis and decreased patient anxiety levels, and increased patient satisfaction are achieved in multidisciplinary clinics compared with other settings[78]. Collaborative care might also inspire multidisciplinary research and quality assurance [42]. An example of such multidisciplinary research is the PACE trial which randomizes participants between surgery and stereotactic radiotherapy in early prostate cancer; recruitment has been shown to be possible between such different modalities within a multidisciplinary clinic context and quality assurance is an important consideration throughout the clinical trial [83].

[H1] Conclusions

Cancer care has undergone a technological revolution over the past 10 years, evolving from general specialties using techniques that had not changed for decades into highly specialized fields in which the pace of innovation threatens to outstrip the ability of medical professionals to educate their trainees in an integrated fashion. How these trainees are expected to keep up with advances relating to their own specialty, let alone the other three pillars of cancer care, is a pressing question that will only be addressed with an integrative training system (BOX 4 and TABLE 1).

This is an exciting time for all cancer-related medical specialties, and great strides have been made towards improving the outcomes for patients. This progress must be matched by a drive to train the next generation of oncologists in an integrated way that prepares them for the challenges ahead. Improving the training in all four pillars of cancer care is achievable, and many of the most striking opportunities require comprehensive knowledge of the other three pillars. For example, in radiation oncology, advanced technologies such as MR Linac[11], proton therapy[84] and molecular radiotherapy (for example, selective internal radiation therapy (SIRT)[8] and ^{223}Ra therapy[85]) must be paired with state-of-the-art imaging, which requires cross-disciplinary input from many professional groups. With the increased precision of cancer-targeting, greater certainty about the location of the tumour and the area most at risk of recurrence are required. Functional imaging (such as multiparametric or whole-body diffusion-weighted MRI and PET[86]), including novel tracers, will be crucial to this effort. The extent to which clinical oncology training can evolve to rapidly accommodate new advances and techniques will be integral to the success of efforts to nurture future oncology leaders — these efforts must start at medical school via provision of students with opportunities to explore the oncological specialties.

To continue the fast-paced improvements in cancer treatment, academically minded oncologists in all four specialties of cancer care must drive forward innovation and research, and mechanisms to integrate research and training need to be promoted. The broad range of skills acquired during dedicated research time will not only enhance the future academic output of the trainee oncologists, but the analytical and logical ways of thinking that such schemes promote will also augment the ability of health-care systems to manage and implement changes.

Cancer care requires mutual interdependence between a wide range of multidisciplinary colleagues, and the adoption of multidisciplinary team meetings is key to delivering the best possible care. Research, training, and patient care benefit from multidisciplinarity, and adoption of this approach will ensure that trainees of all four specialties in clinical oncology are ready to face the new challenges ahead together.

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Author contributions

RAS and ACT conceived the idea for this article and coordinated all activities. All authors researched the data for the article and generated ideas for the content. ACT, VH, AB and VK contributed equally to writing the article and the creation of display items, and all authors for reviewing and/or editing of the manuscript.

Competing interests statement

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Further information

Box 1 | Professional organizations supporting multidisciplinary oncology training

Multidisciplinary meetings

- The British Uro-Oncology Group organizes annual meetings (predominantly for medical and clinical oncologists) and regional training sessions, and is involved in guideline development (http://www.bug.uk.com)
- The British Thoracic Oncology Group organizes annual meeting, and assumes a teaching and advocacy role across lung cancer disciplines (www.btog.org)

Multidisciplinary learning

- The ECCO–AACR–EORTC–ESMO Workshop on Methods in Clinical Cancer Research (formerly known as Flims) includes European and US experts from all oncological specialties as wells as expert clinical trialists, statisticians and radiologists. The workshop represents a fertile environment in which clinical trial ideas can be considered from multiple expert perspectives (http://www.esmo.org/Conferences/Workshops-Courses/Methods-in-Clinical-Cancer-Research-MCCR)
- The ESMO school runs international multidisciplinary courses to enable trainees to learn effectively from and alongside other professionals (http://www.esmo.org/Conferences/Workshops-Courses)

International organizations

- European Society for Surgical Oncology (www.essoweb.org)
- European Society for Radiotherapy and Oncology (www.estro.org/)
- ESMO (www.esmo.org/)

UK national organizations

- The Clinical and Translational Radiotherapy Research Working Group (CTRad) is split into different workstreams aiming to deliver a cohesive response to the challenges of implementing both new technologies [58, 59] and new trials relating to radiotherapy. In addition, they provide a forum for trainees to confidentially discuss a new clinical trial idea with a panel of experts (http://ctrad.ncri.org.uk).
- In the Radiotherapy–Drug Combinations Consortium (RaDCom) leading UK laboratory researchers collaborate with the aim of delivering high-quality preclinical projects, which should inform subsequent clinical research on radiotherapy–drug combinations (http://ctrad.ncri.org.uk/research-support/radiation-drug-combinations-radcom).

Industry collaborations

- Combined research agenda
- Collaborations between academic centres supported by an industry partner
- Synergistic Research and Development work
- Financial, organisational and academic support for meetings and learning opportunities

AACR, American Association for Cancer Research; ECCO, European CanCer Organisation; EORTC, European Organisation for the Research and Treatment of cancer.

Box 2 | Principles of ESMO[22]

- To improve the quality of prevention, diagnosis, treatment, supportive and palliative care, as well as the follow-up of patients with malignant disorders
- To advance the art, science, recognition, and practice of oncology
- To disseminate knowledge in oncology to patients with cancer and the public
- To educate and train persons involved in clinical cancer care and research
- To promote education in oncology in order to ensure a high standard of qualification of medical oncologists within the multidisciplinary team
- To facilitate equal access to optimal cancer care to all patients with cancer
- To maintain liaisons with other oncology specialties, cancer leagues, universities, patient groups and, where appropriate, the pharmaceutical industry

Box 3 | Benefits of participation in trainee-led research collaborations

For trainee

- Experience in research methodology and data analysis
- 'Improved CV' owing to inclusion of publications, presentations and posters
- Acquisition of transferable skills, such as teamwork, leadership, management or public speaking
- Experience in research administration
- Helps trainees achieve excellence in training

For patients

- Improved quality of research
- Increased awareness of patients' needs when trainees frame the research question

For research

- Improved quality of research
- Improved recruitment through trainees
- Increased number of surgical studies
- Increased multicentre collaboration

For region or training scheme

- Improved reputation of scheme
- Helps trainees achieve excellence in training
- Increased research infrastructure in region

Box 4 | Proposed solutions to improve global oncology training

- Formal training in complementary oncology disciplines
- Adoption of competency-based training programmes to allow time for multispecialty training and research exposure
- Embed research training into all oncology training schemes
- Leverage efficiencies of e-learning programmes (such as ASCO's Education Essentials for Oncology Fellows programme), online modules and simulation strategies (http://university.asco.org/education-essentials-oncology-fellows-eeof)
- Reimbursement of health-care costs should favour multidisciplinary clinics and multidisciplinary decision-making mechanisms
- Conferences and training days should prioritize contents related to multidisciplinary learning

Figure 1 | **The four pillars of oncology.** The importance of all four principal oncology specialties is depicted.

Figure 2 | **Examples of functional teams that benefit from strong interdisciplinary collaboration.** Each umbrella shows an example of a functional team required to deliver the optimal package of care. All four specialties are equally important, although the shading within each umbrella represents the specialty that could be tasked with coordinating multidisciplinary work for each of the teams.

Figure 3 | **Academic career pathways for oncology.** The progression of oncology trainees and the opportunities to gain academic experience during training is shown from left to right. The terminology shown is specific to the UK, but principles of training are common across Europe and North America. Approximate timescales are shown as examples, but exact timescales vary between institutions.

Table 1 | Unmet training needs and proposed solutions

Unmet need	**Proposed solution**
Poor trainee knowledge of other pillars of oncology	• Multidisciplinary clinics to facilitate multidisciplinary learning opportunities • Dedicated training time (for example, 3–6 months) spent in other specialty • Structured training metrics to include appreciation of other specialty procedures and treatments
Decision-making made in subspecialty silos	• Multidisciplinary team meetings to promote joint decision-making • Multiprofessional clinics
Inadequate exposure to research methodology and administration	• Encourage trainees to take time out for research (formal research degree or fellowship to gain research skills) • Include integration with clinical trials units into research fellowships
Few opportunities to gain laboratory experience before PhD	• Short (1–2-month) laboratory experience programmes for medical students and residents

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Dion Morton is a Professor of Surgery at the University of Birmingham, UK. Dion received his degree in Medicine from Bristol University, UK, in 1985. He was given an honorary consultant appointment at the University Hospital Birmingham, UK, in 1996, where he was appointed Professor of Surgery in 2006. He is Director of the Birmingham Experimental Cancer Medicine Centre, Director of Clinical Research at the Royal College of Surgeons of England and Deputy Head (Clinical) at the the Institute of Cancer and Genomic Sciences, Birmingham, UK. He is also Chair of the research committee at the European Society of Coloproctology, and President of the Society for Academic and Research Surgery.

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