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JACC REVIEW TOPIC OF THE WEEK

Preparing the Cardiovascular Workforce to Care for Oncology Patients



JACC Review Topic of the Week

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ABSTRACT

Cardiovascular disease and cancer are the 2 main causes of death in the United States. They intersect on multiple levels, sharing common causal mechanisms and epidemiological risk factors. The growing prevalence and complexity of cardiovascular disease and cancer have resulted in the development of the discipline of cardio-oncology. Preparing the cardiovascular workforce for the care of a growing population of cancer patients is necessary to enhance the delivery of high-quality cardiovascular care for patients with cancer. The goal of this review is to present the dedicated efforts of the cardio-oncology community to meet the growing need for education and training of cardiovascular practitioners providing care to cancer patients and survivors. Integration in general cardiology training programs and the efforts of the stakeholder organizations serve as an example of how a multidimensional, innovative approach can address provider education and training needs in a relatively new discipline. (J Am Coll Cardiol 2019;73:2226-35)
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THE NEED FOR TRAINING AND EDUCATION IN CARDIO-ONCOLOGY

Close to 5,000 new cases of cancer are diagnosed each day in the United States, and over 15 million individuals with a history of cancer are alive today (1,2). Advances in early detection and treatment have led to

a decrease in cancer-related mortality and an unprecedented rise in the number of cancer survivors. By 2026, there will be an estimated 20 million survivors, of which almost one-half would be of age 70 years or older (1-3). An aging population with a history of cancer and comorbid cardiovascular (CV) disease, and an increasingly diverse array of cancer

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HIGHLIGHTS

- Cardio-oncology has emerged as a discipline and subspecialty in response to the rapidly growing number of patients with cancer at risk of, or with comorbid cardiovascular disease.
- Specialists in cardio-oncology are involved in all aspects of the care of cancer patients: from informing pre-treatment risk and regimen selection, addressing the complex cardiovascular adverse effects of cancer therapy, and mitigating the heightened long-term risks of cardiovascular disease in survivorship.
- Centers offering cardio-oncology services have doubled in number since 2014, and close to one-half of cardiovascular training programs incorporate cardio-oncology topics in their core curriculum.
- The future of the discipline is dependent on the collaboration with oncology and defining competencies around which an effective training structure for providers can be built.

treatments with complex, but incompletely understood, effects on the CV system have created a need for CV specialists with an in-depth understanding of the pathophysiology and risk factors underlying adverse CV events; and the development of the discipline of “cardio-oncology” (4,5).

Cardio-oncology, also known as onco-cardiology, is a term ascribed to the developing discipline of practitioners who are focused on the prevention, early detection, and optimal treatment of CV disease in patients treated for cancer, focused on balancing the CV and oncological needs of patients before, during, and after therapy. Examples of clinical strategies include pre-therapy risk stratification and CV health optimization, personalizing cancer therapy based on the CV risk profile, and the diagnosis and treatment of a widening array of therapy-related CV complications (5,6). The cardio-oncology care team works to guide patients through all the stages of cancer management; from the cancer diagnostic workup to survivorship (5,6). The number of CV specialists in cardio-oncology in the United States does not meet the health care needs of the rapidly expanding population of patients on cancer treatment with emerging or pre-existing CV disease and cancer survivors

experiencing the long-term adverse effects of therapy (5,7). Moreover, the vast majority of CV training programs provide limited exposure to the field of cancer therapeutics and its impact on CV health; exacerbating the unmet need for CV professionals in cardio-oncology. In response to growing clinical demand, there is a small, but increasing, number of cardio-oncology training programs located mainly in quaternary referral centers with large comprehensive cancer centers.

In this paper, we summarize the current state of CV training in cardio-oncology and discuss education of the CV specialist in cardio-oncology. We present the role of stakeholder organizations in the education of health care providers and highlight the needs and opportunities for partnership across institutions, societies, and organizations invested in advancing the care of the cancer patient with or at risk for CV disease. We provide a framework for the training of the CV workforce in this new subspecialty (Central Illustration).

ROLE OF THE CV SPECIALIST IN CARDIO-ONCOLOGY

The field of cardio-oncology initially emerged with the expanded use of anthracyclines in the therapeutic regimens of various cancers, and the rise in cardiotoxicity exemplified by doxorubicin-induced cardiomyopathy (8). The explosion in the number of novel therapies in recent years has led to a paradigm shift in the approach to the treatment of cancer from the use of standard regimens to targeted therapies based on individualized susceptibility (9). The beneficial effects of these therapies has however been offset by adverse CV effects, of which the mechanisms are poorly understood, and clinical manifestations include heart failure, coronary, peripheral, and pulmonary vascular disease, arrhythmias, hypertension, and thrombosis (9-11). Valvular disease and premature atherosclerosis of the coronaries occur as long-term consequences of radiation therapy, imparting an increased risk up to 40 years after therapy (12). Thus, the potential adverse impact of cancer therapy encompasses the breadth of CV disease, and demands of the health care provider specialized knowledge of these disease states beyond that acquired from the general CV training; as their presentation, clinical course, and treatments in cancer patients can be unique (8-13). An in-depth understanding of how malignancies themselves and their treatments impact CV pathophysiology form the cornerstone for developing strategies to optimize CV

ABBREVIATIONS AND ACRONYMS

ACC = American College of Cardiology

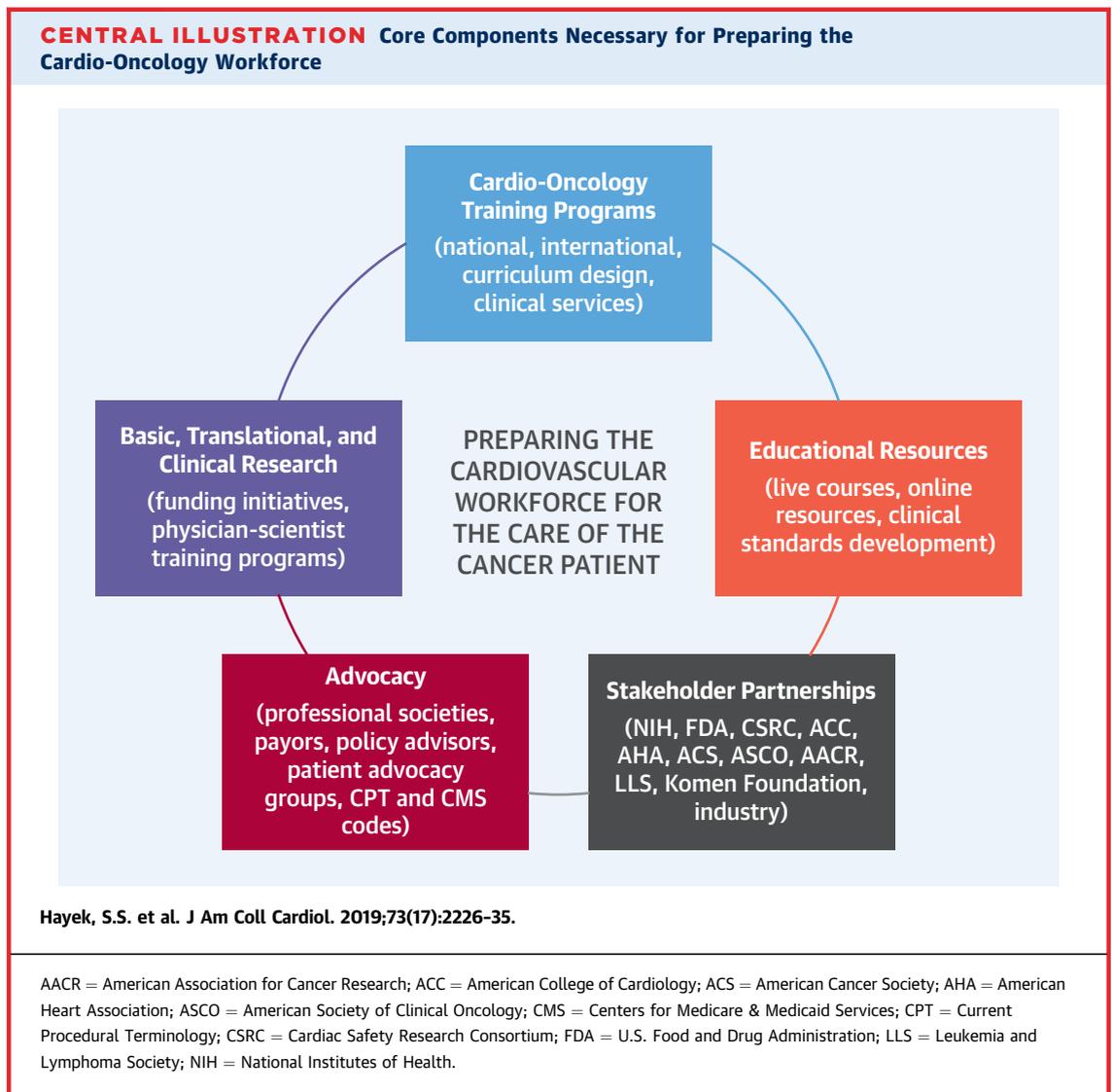
ACGME = Accreditation Council for Graduate Medical Education

AHA = American Heart Association

CV = cardiovascular

NCI = National Cancer Institute

NHLBI = National Heart, Lung, and Blood Institute



health and prevent and treat CV complications in the cancer patient (9).

Prevention begins with optimization of CV health through aggressive management of risk factors, which are often common to both cancer and CV disease (14). The availability of a wide array of cancer therapies offers the opportunity for the CV specialist in collaboration with the oncologist to devise CV risk-profiling and stratification strategies which aim to identify patients at high risk of CV events and select the therapies that would confer the best risk-to-benefit ratio. These strategies may involve measuring novel biomarkers and incorporating advanced CV imaging including echocardiographic strain analysis and cardiac computed tomography, as conventional risk stratification algorithms such as the

Framingham risk score may underestimate CV risk in patients with cancer (15-17).

The management of CV complications related to cancer therapy poses unique challenges given the lack of evidence-based guidance in this population often excluded from CV trials. For example, the management of cardiomyopathy secondary to agents such as doxorubicin and trastuzumab may be complicated by hypotension, drug interactions, and intolerance of neurohormonal antagonists (18). Similarly, thrombosis, anticoagulation, and percutaneous coronary interventions in patients with cancer require complex decision making to balance the increased bleeding risks due to bone marrow suppression and thrombocytopenia, multiorgan dysfunction, and the thrombotic tendencies

associated with malignancy and antineoplastic agents (19,20). Unpredictable blood pressure fluctuations during antiangiogenic therapy with tyrosine kinase inhibitors require tailoring of antihypertensive therapy and close blood pressure monitoring to prevent hypertensive crises and subsequent complications (21). Ibrutinib, which is commonly used to treat B-cell lymphomas, is associated with an increased risk of both atrial fibrillation and bleeding, posing a unique challenge in anticoagulation management (22). Immune checkpoint inhibitors, which have led to dramatically improved cancer-related outcomes, have been associated with rare, but fulminant, myocarditis (23,24).

These are only a few examples that highlight a spectrum of challenges faced by the CV specialist in cardio-oncology. A multidisciplinary approach involving oncology and often multiple CV subspecialties is necessary for optimal management of these complex clinical situations. Although still limited in number and scope, training programs across the country are emerging to meet the educational needs for cardiovascular care providers of patients with cancer.

CURRENT STATE OF FORMAL TRAINING IN CARDIO-ONCOLOGY

To define the overall number and geographical distribution of cardio-oncology training programs and better characterize whether and how CV disease training programs provide exposure to cardio-oncology, we conducted a nationwide survey of Accreditation Council for Graduate Medical Education (ACGME)-accredited General Cardiology fellowships. An e-mail containing a link to an electronic survey was sent in November 2017 to CV fellowship program directors. Initial nonresponders were contacted by phone in July 2018 and encouraged to complete the survey. Of 206 programs contacted, 104 (50%) accessed the survey and 81 (39%) provided at least partial responses.

Amongst responders, 41 (51%) were part of institutions that provided dedicated cardio-oncology services. In comparison, a prior survey performed in 2014 suggested only 27% of centers had an established, specialized cardio-oncology service with multiple clinicians (5). Of those that were not, 13 (33%) were planning on offering these services in the near future. Geographically, most institutions offering or planning to offer cardio-oncology services (n = 53) were spread across the United States, with a notable concentration in the Northeast (n = 22) and California (n = 7). Only 9 programs had training

opportunities specific for the field of cardio-oncology, offering clinical observerships lasting <6 months (n = 5), dedicated training programs of 6 months or less (n = 3) and at least a year (n = 5). All required prior cardiovascular fellowship training.

Close to One-half (n = 37, 46%) of CV training programs incorporated regular educational topics pertaining to the oncology patients, encompassing cancer therapy-related cardiotoxicity, complications of radiation therapy, risk stratification, thromboembolism, and management of cancer survivors (Table 1), with 39% dedicating at least 3 to 5 lectures to cardio-oncology. The training programs in centers that provide cardio-oncology services were more likely (55% vs. 27%) to include related educational topics in their core curriculum.

CURRENT NON-ACGME CARDIO-ONCOLOGY TRAINING MODELS.

Due to the relative infancy of the field compared with other subspecialty fields within cardiology, fellowship programs within cardio-oncology are limited on a national and international scale, with <10% of CV programs offering focused training opportunities. Common aspects of these fellowship programs involve at least 1 to 2 days a week in a cardio-oncology outpatient clinic, providing inpatient consultative services, involvement in multidisciplinary meetings with hematology/oncology (e.g., tumor board attendance), and training in advanced heart failure, cardiology preventative medicine, or multimodality imaging. These are often coupled with dedicated time for clinical and basic science research.

CARDIO-ONCOLOGY TRAINING PROGRAMS OUTSIDE THE UNITED STATES.

The need for specialists in cardio-oncology extends beyond the United States, and highly specialized centers across the world are starting to provide services. The number of formal training opportunities in the Americas and Europe are growing rapidly. Currently, most opportunities offered are in the form of workshops and courses. Others have shaped programs similar to that of the United States. For example, the University of Ottawa offers a Cardiac Oncology Research fellowship that includes a clinical component, attending both oncology and cardiovascular clinics. In Sao Paulo, Brazil, the Instituto do Cancer do Estado de Sao Paulo has offered up to 3 fellowship training positions per year. The Royal Brompton Hospital in the United Kingdom similarly provides opportunities for a specialist to join a multidisciplinary team managing both inpatient and outpatient cardio-oncology services. Italy has a large number of hospitals of various sizes offering cardio-oncology services, and Associazione Nazionale Medici Cardiologi Ospedalieri in

TABLE 1 Barriers to Establishing a Cardio-Oncology Training Program

Challenges		Potential Solutions
Institutional support for an overall cardio-oncology program	<ul style="list-style-type: none"> Professional/academic obligations of faculty with limited time to invest in new interests Geographical barriers (clinical practices physically separated by long distances) Concern from oncologists of potentially having to limit or delay therapy based on a cardiovascular evaluation 	<ul style="list-style-type: none"> Integrate practices within or very close to cancer centers and build volume, justifying the need for a dedicated cardio-oncology program Grand rounds attendance and presentations, frequent feedback with hematology/oncology colleagues regarding shared patients Availability for urgent referrals and imaging requests Targeted outreach to oncologists Development of billing codes relevant to cardio-oncology
Financial support	<ul style="list-style-type: none"> Cardio-oncology fellowships are currently non-ACGME approved and thus hospital support may be limited without accreditation Research/institutional support delegated elsewhere within division deemed "higher priorities" 	<ul style="list-style-type: none"> Enroll in clinical trials both in hematology/oncology and cardiology to generate revenue to support faculty and ancillary staff for a cardio-oncology training program Increase private sector support Research grant funding for fellowship funding (i.e., NIH, Cancer Center-related seed funds, T32 teaching grants, industry support grants, foundation support)
Designing an optimal educational curriculum	<ul style="list-style-type: none"> No official, ACGME/ACC/AHA-sponsored educational curriculum to date or COCATS equivalent Many institutions have varying cancer populations, which may make the spectrum of cardio-oncology-related issues very heterogeneous and inconsistent Limited evidence-based guidelines for management of alternative cardiac effects of other cancer treatments Rapid expansion of oncology drugs with limited long-term cardiovascular follow-up 	<ul style="list-style-type: none"> Didactics and education sessions need to be integrated into general cardiology fellowship training until accreditation of a fellowship is established Ongoing national efforts to design a cardio-oncology training curriculum that fit the heterogeneous nature of multiple health care systems, both in community and academic centers Determine outpatient and inpatient experience and patient volume, as well as different cancer/cancer treatment types that a competent cardio-oncologist should be exposed to
Varying access to imaging technologies	<ul style="list-style-type: none"> Cardio-oncology centers have variable access to imaging modalities (i.e., echo, CT, MRI, vascular imaging) Imaging faculty may hesitate to embrace cardio-oncology applications of imaging due to time constraints and lack of payer reimbursement 	<ul style="list-style-type: none"> Frequent collaboration and education of imaging colleagues in cardiology, radiology, and vascular medicine on screening and diagnosing cardio- or vasculotoxicity in cancer patients Consider external rotations for trainees, if home institutions do not have access to advanced technologies
Research programs	<ul style="list-style-type: none"> Limited funding Limited interest to develop careers as physician scientists Limited institutional support Overall paucity of national/international cardio-oncology collaborations and guidelines 	<ul style="list-style-type: none"> Ongoing training and increased awareness amongst Internal medicine, cardiology, and hematology/oncology house staff, to inspire and recruit future generations to conduct clinical/basic science/translational and clinical research National and international efforts to promote registry data collection Ongoing application to national grants (e.g., NIH, AHA, American Cancer Society, Leukemia and Lymphoma Society, and other organizations) and investigator-initiated industry support from cardiology and hematology/oncology physician scientists

ACC = American College of Cardiology; ACGME = Accreditation Council for Graduate Medical Education; AHA = American Heart Association; COCATS = Core Cardiology Training Symposium; CT = computed tomography; MRI = magnetic resonance imaging; NIH = National Institutes of Health.

collaboration with other European Societies have provided clinical and management pathways (25,26). The International Cardio-Oncology Society, which includes specialists from around the world, has also released a consensus document delineating guidelines for training in cardio-oncology (27). Beyond the Americas and Europe, there are little data available on cardio-oncology services and training opportunities; despite many of these countries now bearing the bulk of the global burden of cancer (28). The barriers and challenges are typically resource-related, where many interventions and expertise remain inaccessible for many people (28). There is, however, increasing recognition of the importance of cardio-oncology; in the Middle East, the Iranian Joint Cardiovascular Congress in 2016 was the first to have a focused scientific session on cardio-oncology (29). These are only a few examples of the training

opportunities and educational opportunities that exist internationally.

PEDIATRIC CARDIO-ONCOLOGY PRACTICES. Cancer is diagnosed in 15,700 patients <20 years of age each year in the United States. Although this number is significantly lower than that for adults, with current 5-year survival at 80% for all types of pediatric and young adulthood cancers, there are ~450,000 survivors of pediatric cancer in the United States alone (30). Survivors are 5 to 6 times more likely than sibling controls to develop cardiovascular disease of various etiologies (31). Unfortunately, data and practice guidelines in pediatric patients are lacking, particularly for those actively undergoing and recently completing therapy as opposed to adult survivors. Consequently, practitioners often default to applying recommendations formulated for adult

patients despite many potential physiological and treatment differences. Moreover, there is no formalized training for pediatric cardio-oncology, and with limited patient numbers formal training as a separate subspecialty may not be feasible. Ongoing efforts by the American College of Cardiology (ACC) Cardio-Oncology Member Section are focused on determining current patterns of practice in the field, including which providers care for this diverse population, how they are followed, and in what specific settings.

EDUCATIONAL RESOURCES

The 2015 ACC survey in cardio-oncology identified the lack of educational resources in cardio-oncology as one of the important challenges in developing training programs (5). Over the most recent years, a number of live courses have been developed to meet the needs of the field. Moreover, there are a greater number of cardio-oncology-focused sessions at national meetings, including the ACC, American Heart Association, American Society of Clinical Oncology, American Society of Echocardiography, Society of Cardiovascular Magnetic Resonance, and the American Association of Cancer Research, to name a few. There are now a number of journals dedicated to the dissemination of original cardio-oncology-related research and educational material including *Cardio-Oncology* from BioMed Central and the upcoming *JACC: CardioOncology*.

LIVE COURSES. Over recent years, an increasing number of dedicated international and regional live cardio-oncology courses have been sponsored by professional societies such as the ACC and International Cardio-Oncology Society, comprehensive cancer centers, as well as several academic institutions. Overall, a growing number of participants across many of the courses and expanding program agendas serve as a testament of the need and interest of health care providers and trainees in this area. The ACC's Advancing Cardiovascular Care of the Oncology Patient has, for example, focused on inclusion of advance practice providers as well as dedicated discussion on coding and billing as part of the instruction of cardio-oncology practice development. Another distinct characteristic of cardio-oncology courses is the multidisciplinary nature of faculty and sessions, featuring perspectives from both oncologists and cardiologists.

ONLINE RESOURCES. A growing number of online resources are offering curated content for providers addressing relevant topics in the management of cardiovascular disease in patients with cancer.

The ACC website provides a cardio-oncology Clinical Topic Collection that links to content organized into 30 topics and almost 100 subtopics in the field of cardio-oncology, targeting providers and trainees. The clinical collection page receives >1,500 visitors monthly. CardioSmart is an online educational resource also sponsored by the ACC that is focused on patient education (32). In 2017, the ACC Cardio-Oncology Council in partnership with the National Cancer Institute (NCI) funded Eastern Cooperative Group/American College of Radiology Imaging Network's Cardiotoxicity Working Group developed modules focused specifically in cardio-oncology, which provide an evidence-based, expert-consensus based educational toolkit to both patients and providers in this relatively new field.

CLINICAL PRACTICE STANDARDS DEVELOPMENT.

The lack of guidelines was identified as one of the key limitations of the growth of cardio-oncology in the 2015 ACC Survey (5) and various clinical practice documents and position papers have been developed since to assist health care professionals caring for cancer patients. The National Comprehensive Cancer Network guidelines, American Society of Oncology clinical practice guidelines, American Society of Echocardiography and the European Association of Cardiovascular Imaging expert consensus, and Canadian Cardiovascular Society guidelines are a few examples of the available documents and resources (33-36). More recently, the American Heart Association (AHA) has released a statement regarding the management of cardiovascular disease in patients with breast cancer (37). These consensus documents represent summaries of the available literature and expert consensus; however, it is important to note that the final decisions concerning an individual patient must be made in a collaborative manner among responsible health care professionals involved in patient care and in shared decision making with the patient and caregiver. The guidelines have focused on common clinical challenges with cardiotoxic cancer therapies, such as identifying patients at risk for cardiac dysfunction related to cancer therapy by evaluation of clinical risk factors, incorporation of imaging best practices, implementation of protocols for cardiovascular monitoring during cancer therapy, and strategies to prevent and treat cardiotoxicity and long-term sequelae of cancer therapy. The great majority of recommendations are based on expert opinion, highlighting the need for ongoing research to generate high quality evidence to guide clinical management (33-36). An important next step will be

development of practical guidance for cardiovascular care with specific cancer regimens.

ROLE OF PARTNERSHIP IN ADVANCING THE FIELD OF CARDIO-ONCOLOGY

MULTIDISCIPLINARY COLLABORATIONS. The field of cardio-oncology in its essence is multidisciplinary and requires the collaboration of various stakeholders, extending from multispecialty health care providers, basic science and clinical investigators, regulatory bodies, and advocacy groups. Traditional care models in which cardiologists and oncologists operate in silos are suboptimal for managing complex cancer patients, and lead to fragmented care and variability in assessment and management. Most importantly, the viability of any cardio-oncology program is dependent on collaborating oncologists who form the referral base. Oncologists need to perceive the benefits of cardio-oncology services. Strategies to help cultivate these relationships include regular joint educational conferences, case reviews and discussions, joint initiatives by the professional societies of both specialties, but most importantly, frequent communication between the cardio-oncology specialist and the referring oncologist. As relationships develop and a referral base is established, an integrated approach to the care of the cancer patient is necessary and based on systematizing the collaboration between oncologists, cardiologists, pharmacists, and advanced practice providers to design streamlined, yet individualized, plans of care for patients, ensuring close follow-up and communication between care team members.

RESEARCH INITIATIVES. Research is an essential component in advancing the cardiovascular care of the cancer patient, as this patient population is highly heterogeneous and has typically been excluded from the cornerstone cardiovascular trials.

An increase in broad funding initiatives and collaboration between the NCI and National Heart, Lung, and Blood Institute (NHLBI) and the scientific community are warranted to bridge important knowledge gaps in cardio-oncology. The NCI developed a Community Oncology Task Force, composed of community clinical oncologists, cardiologists, and NCI program staff from the Division of Cancer Prevention, Division of Cancer Control and Population Sciences, and the Division of Cancer Treatment and Diagnosis Cancer Therapy Evaluation Program. The mission of this task force is to collaborate and assist in prioritizing the cardio-oncology research agenda and issues across funded research bases in the NCI Community Oncology Research Program. There has been a

substantial focus by the NCI and NHLBI on ensuring that clinical trial designs evolve to balance subclinical and clinical cardiovascular disease and oncology drug effectiveness.

Together, the NCI and NHLBI have hosted a number of workshops defining the current state of basic and clinical evidence in the field, prioritizing important areas in need of greater evidence. The first was in 2013, and this led to the development of program announcements soliciting NIH proposals in clinical research (PA 18-003, PA 18-013 with the clinical trial option) (38). The follow-up meeting was held in June 2018 to reassess the current funding climate and research advances in the field over the past 5 years. Moreover, the NCI has offered grant funding opportunities to independent investigators focusing on the study of cancer therapy-induced organ toxicity, including cardiovascular toxicity (RFA CA18-019). Specific initiatives in hematopoietic cell transplantation late effects have also been sponsored by the NIH, reflecting priorities set forth in the NHLBI strategic vision (39). Lastly, the cardio-oncology community is advocating for greater alignment between regulatory bodies such as the Food and Drug Administration and the Cardiac Safety Research Consortium to improve adjudication of cardiovascular endpoints in drug trials in cancer patients, and to inform policy makers and payers on the importance of the field of cardio-oncology. Both societies held workshops in 2017 focused on cardio-oncology; the Food and Drug Administration on immunotherapy toxicity and detection (40), and the Cardiac Safety Research Consortium on the detection and assessment of cardiac safety signals in oncology drug development.

ROLE OF PROFESSIONAL SOCIETIES. Professional societies have an important role in advancement of any field by identifying and meeting professional needs of their members. This often includes education, training and research: for example, the mission of the ACC cardio-oncology Section includes advancement of each of these areas to provide professional home for its members. In addition, professional societies represent important partners for advocacy and opportunities for interdisciplinary collaboration with multiple stakeholders. A recent example is the organization 2018 Heart House Roundtable on Cardiovascular Function and Cancer treatment that brought together a diverse group of stakeholders to identify challenges and opportunities to improve cardio-oncology care (41). The International Cardio-Oncology Society has held a monthly webinar of expert case reviews for the past 6 years

and have formed an official partnership with the journal *CardioOncology* in order to publish high-quality manuscripts in this discipline.

ADVOCACY EFFORTS. The expanding field of cardio-oncology faces several challenges as a result of caring for highly complex patients whose problems span across several specialties. Thus, in tandem with educating and expanding the workforce, it is imperative that those legislating and implementing health care policy understand and appreciate the unique role of the cardio-oncology specialist. The Advocacy working group of the ACC Cardio-Oncology Council is dedicated to educating lawmakers and policy advisors, as well as payers, to provide increased training opportunities, and fund research in cardio-oncology. This allows coordination with advocacy activities of the ACC and empowers the group with knowledge and experience of collaboration with other sections. Issues currently being addressed include facilitating the process of pre-authorization to alleviate the burden of patients and health care providers and prevent delays in treatment. Partnership with advocacy efforts of oncology organizations represents an important goal. The creation of new Current Procedural Terminology and obtaining Center for Medicare & Medicaid Services taxonomy codes for cardio-oncology will be necessary in order to provide adequate reimbursement for advanced services provided.

DEFINING CV TRAINING IN CARDIO-ONCOLOGY: CHALLENGES AND FUTURE STEPS

Guidelines for training in cardiovascular medicine and its subspecialties in the United States are established and updated by the Core Cardiology Training Symposium's various task forces, with regulatory oversight by the ACGME and its Internal Medicine Residency Review Committee (42). Training in cardiovascular medicine is often defined by the development of competencies, with achievement of curricular milestones leading to the acquisition of specific skills (42). In cardio-oncology, there has been a concerted effort of many in the field to define a complete set of competencies (27,43-47). Incorporating required competencies, for example, questions related to cardio-oncology on American Board of Internal Medicine certification and recertification examinations, may incentivize general training programs to support dedicated educational efforts within cardio-oncology.

The gamut of CV skills and knowledge; and what defines the "expert" includes a deep understanding

of the pharmacotherapies, risk factors, prevention, complications, and treatment of cardiovascular disease in cancer patients. This can also potentially be a challenge given the breadth of possible cardiovascular diseases that a cancer patient faces. Training the specialist in cardio-oncology relies on an intimate knowledge of cardiovascular medicine including risk stratification, preventive medicine, cardiac imaging, arrhythmias, vascular medicine and thromboembolism (46). Experience in evaluating and managing patients with cancer, and working directly with oncologists both in the outpatient and inpatient setting is an absolute necessity. Given the increasingly important role of echocardiography, cardiac magnetic resonance imaging, an emphasis on acquiring expertise in multimodality imaging may be necessary. Research and scholarly activity are of utmost importance, given the dearth of evidence-based management strategies in this nascent field. A subspecialty training curriculum of up to 1 year would build on the general cardiovascular competencies and should likely include: 1) a strong outpatient focus, with rotations in already established cardio-oncology, heart failure, and various oncology clinics; 2) inpatient consultative services focused on cancer patients, including embedding the cardiovascular specialist in primary oncology services such as the bone marrow transplant unit; 3) dedicated time for imaging to achieve level III competency in other cardiovascular subspecialties such as heart failure or prevention; and 4) involvement in scholarly activities that are collaborative likely across disciplines and centers. Detailed strategies toward building a successful training program are beyond the scope of this discussion, but have been described in prior literature (46,48).

BARRIERS TO TRAINING IN CARDIO-ONCOLOGY.

Although efforts are ongoing in designing an educational structure to cardio-oncology training, certain barriers have made it difficult to define the required competencies and establish formal training programs, including the lack of: 1) funding and logistical support; 2) an accreditation process (i.e., ACGME); 3) a formalized training curriculum; and 4) evidence regarding clinical benefit and economic feasibility of interventions within the field (Table 1) (27,46). In addition, a training program can only effectively exist and thrive in conjunction with well-established cardio-oncology services with robust patient and imaging volume as well as ongoing clinical and basic science research activities (49). The number of cardio-oncology programs has grown rapidly, and each has adapted to individual vision of the

leadership and the particular needs of the local population of patients with cancer. The heterogeneity of the infrastructure in medical centers across the country adds to the challenge of providing a uniform training curriculum that can be effectively applied on a national scale.

Cancer patients present with a plethora of concomitant medical issues, and unlike other aspects of cardiovascular disease, the multiple iterations of these clinical scenarios have not been studied on a large scale. Thus, achieving a symbiotic relationship in both the clinical and research realms with the affiliated cancer program is critical to improve the quality of patient care and training on both sides of the aisle. Other challenges are intrinsic to the nature of the field; the rapid growth in knowledge paralleling the development of new oncological treatments and discovery of potential toxicities leads to constantly shifting clinical care protocols.

CONCLUSIONS

Overall, the field of cardio-oncology has witnessed unparalleled growth, building on the momentum of collaborative efforts, and exponential increase in publications, attendance of courses, and other academic activities. In 4 years, the number of cardio-oncology training programs has doubled; a testament to the rising interest in the field and the recognition of the health care needs of a fast-growing segment of patients. Given the highly specialized nature of the field, it may be necessary to establish cardio-oncology as a universally recognized subspecialty of cardiology and oncology similar to heart failure, imaging, and preventive cardiology. In

parallel to ongoing efforts to formalize a cardio-oncology training curriculum and an accreditation process for a fellowship training program, it is necessary to integrate components of cardio-oncology into general cardiology training programs (46). Definition of “competencies” will include core aspects including cancer therapy and radiation-induced cardiotoxicity, multimodality imaging, interventional therapies in diagnosing therapy-induced pericardial disease and restrictive cardiomyopathy, cardiotoxicity of immunotherapy, and vasculotoxic sequelae of treatments, management of arrhythmias and dysautonomias, as well as arterial and venous thromboembolic phenomena associated with cancer. Inclusion of cardio-oncology as a component of general cardiology training programs is the first step at establishing a workforce capable of recognizing and managing the complex cardiovascular burdens associated with cancer in every community.

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