

QUALITY IMPROVEMENT

Assessment of Oncology Provider Knowledge and Cardiovascular Screening Practices: A Call for Heightened Screening

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Authors' disclosures of conflicts of interest are found at the end of this article.

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Abstract

Cardiac risk factors are known to compound the development of cardiotoxicities (CTx) in patients exposed to anthracycline (ANT) chemotherapy agents. National oncology and cardiology organizations have published recommendations for cardiovascular risk stratification and screening cancer patients following exposure to ANTs. The frequency with which oncology providers are integrating these principles into practice is unknown. This knowledge-based quality improvement (QI) project was designed to heighten oncology provider competencies such that screening frequency of cancer patients for CTx in the post-ANT setting aligns more closely with national guidelines for care. A web-based educational intervention, cardiac screening tool, and evidence-based literature were shared with 20 oncology providers over the course of 5 months. Retrospective chart reviews and pre- and post-project surveys were performed to assess competencies and practice trends. Qualitative and quantitative data were analyzed to illustrate whether the interventions improved knowledge and changed practice. Findings revealed an increase in the number of provider-perceived percentage of high cardiac risk patients and the number of patients screened, knowledge did not improve, and the frequency by which oncology providers ordered echocardiograms increased minimally. Factors such as organizational system changes, time constraints, and change fatigue limited effective and consistent implementation of the project interventions. The trajectory of cancer survivorship is affected by cardiovascular disease. Cardiac screening of cancer patients is a critical component of cancer care that has the potential to positively impact economic and health outcomes of this susceptible population.

Advancements in screening technologies and increasingly effective novel treatments for cancer have led to vast improvements in cancer survival rates. The improved outcomes have changed the demographics of cancer survivors to a larger population of aging individuals who are subject to late-onset sequelae of cancer therapies (Shapiro, 2019). The literature describes a growing number of cancer survivors and a noticeable increase in the incidence of cardiovascular (CV)-associated morbidity and mortality in this population. National guidelines suggest oncology providers incorporate cardiac screening and preventive measures into practice for high cardiac risk cancer patients exposed to cardiotoxic treatments (Ganz, 2009; IOM, 2005; NCCN, 2019). The frequency with which these guidelines are integrated into practice is unknown.

CARDIOTOXICITIES AND CARDIOVASCULAR RISK FACTORS

Of the many long-term sequelae of cancer treatments, cardiotoxicities (CTx) have captured the attention of cardiology and oncology communities alike. Cancer treatment-associated CTx is a term that encompasses a diverse range of functional or structural heart injuries that occur secondary to chemotherapy, radiotherapy, or the combination thereof. It is a continuous process that begins with exposure to the causative agent, may evolve over time, and can accelerate the development of chronic diseases (Clark et al., 2017; Lenneman et al., 2017; Minasian et al., 2020). Therefore, it is vital to identify which cancer patients for whom cardiotoxic anticancer therapies are being considered are at risk of developing CTx.

The literature supports a statistically significant increased risk of CTx with specific cancer treatment agents, which are "...superimposed on physiologic and structural changes that accompany aging..." and are higher in patients with cardiac risk factors such as smoking, diabetes, and hypertension (HTN; Lenneman et al., 2017; Minasian et al., 2020, p. 650). Kosalka and colleagues (2019) found that the combination of two or three comorbidities, including dyslipidemia, obesity, and diabetes, significantly increased the incidence of cardiac dysfunction in a population of breast can-

cer patients. The incidence of late-onset anthracycline (ANT)-associated congestive heart failure (CHF) is increased (58%) in patients presenting with HTN, which is the most common comorbidity in cancer registries (30%; Jain & Townsend, 2007; Kuriakose et al., 2016).

Anthracycline-Associated Cardiotoxicity

Anthracycline agents (daunorubicin, doxorubicin, epirubicin) have been the backbone of treatment for multiple tumor types, including breast cancer, lymphomas, and sarcomas, and have known associations with cardiac events (Henriksen, 2018). Late-onset ANT-associated CTx is often insidious in onset and can progress to irreversible dilated cardiomyopathy (CM) and heart failure. It is therefore associated with poor prognosis and survival (Babak & Brezden-Masley, 2018). It is suggested that over half of patients exposed to an ANT will show some degree of cardiac dysfunction, with 5% developing heart failure (Cardinale et al., 2010). Larsen and colleagues (2018) illustrated people treated with an ANT for lymphoma and breast cancer were at significantly increased risk of CHF after the first year of exposure, a risk that persisted up to 20 years after exposure. Independent risk factors include cumulative dose, associated chest radiotherapy, African-American ethnicity, age > 65 years or < 18 years at the time of exposure to an ANT, diabetes, HTN, very high or very low body weight, or severe comorbidities (Lotrionte et al., 2013). Early detection of ANT-associated CTx and intervention are critical to interrupting progression, initiating recovery, and improving outcomes (Ghojallu et al., 2016).

National oncology and cardiology organizations recommend more comprehensive risk stratifying, screening, and measures to mitigate the development of cancer treatment-associated CM. It is suggested that cardiac risk stratifying and post-ANT echocardiograms (ECHOs) in this population have the potential to identify CM at an earlier point on the disease spectrum, thus leading to better management and lower rates of CV-related morbidity and mortality in cancer patients. Standard-of-care screening includes ECHOs before ANT exposure and has been observed in the project setting. Left ventricular ejection fraction (LVEF) surveillance in high-risk patients is rec-

ommended 6 to 12 months after completion of therapy (Armenian et al., 2016).

PURPOSE

The literature supports implementing best practice for cardiac screening of cancer patients can improve outcomes of care (Armenian et al., 2016). The purpose of this project was to determine whether sharing of evidence-based literature heightened oncology provider knowledge of CTx and changed practice behaviors such that they aligned more closely with evidence-based American Society of Clinical Oncology (ASCO) and National Comprehensive Cancer Network (NCCN) recommendations. The primary aim was a 25% increase in frequency by which oncology providers order post-ANT exposure ECHOs for high cardiac risk cancer patients with histories of breast cancer, lymphoma, and sarcoma over a 5-month window. Secondary aims included a 25% increase in provider competencies of echocardiographic evaluation of cardiac function (LVEF, global longitudinal strain [GLS]) as predictive markers for late-onset ANT-associated CTx, drug-associated CTx, and risk factors for ANT-associated CTx; a 25% increase in provider-reported cardiac risk stratifying and awareness of at-risk cancer survivors; and identification of individual and organizational barriers and facilitators to practice change in this health-care setting.

METHODOLOGY

Project design

This quality improvement (QI) knowledge-based project was designed to obtain quantitative and qualitative data that assessed provider competencies and practice behaviors before and after the implementation of the interventions. Providers voluntarily attended a web-based presentation and were then asked to use a cardiac screening tool during the project implementation. Surveys were voluntarily and anonymously completed before and after the implementation phase to assess competencies and provider perception of high cardiac risk patients and screening practice.

Kotter's 8-Step Change Model is an actionable eight-step process used for implementing effective organizational change and was used as a theoretical framework for the project (Williams,

2014). Each step is generated from one of eight predictable errors organizations commonly make when implementing change (Kotter, 1996). Kotter's 8-Step Change Model served as a guide to help understand the best approaches to effectively disseminate knowledge and enhance the rates by which the evidence-based medicine (EBM) was adopted, implemented, and integrated into practice. Table 1 depicts how each step was applied to this project.

Project Population and Setting

A convenience sample of 20 participants including nurse practitioners and physician assistants (advanced practice providers [APPs]), and medical doctors (MDs) who work in three outpatient hematology medical oncology clinics were approached, twelve of whom completed surveys. Providers within this organization manage and treat cancer patients across the cancer continuum. Providers were approached via email and face-to-face invitations. The project met institutional review board criteria for a declaration of exemption from review, as it did not meet the current descriptions for human subject research. Therefore, informed consent was not required for this project.

Project Procedures

The methods used to recruit participants included face-to-face invitations, printed invitations, and an internal email, all of which summarized the project aim, intervention, duration, and the date, time, and content of the introductory presentation. An email invitation with a link to complete the pre-project online SurveyMonkey survey was sent to providers before the educational presentation. Thereafter, participants were to use the screening tool over the 5-month course of the project and order ECHOs when clinically indicated. Post-project survey invites were similarly emailed at the end of the fourth month of the implementation phase of the project.

The project incorporated a web-based educational presentation on screening and monitoring cancer patients for CTx, a risk stratifying cardiac screening tool adapted from the ASCO and NCCN guidelines, and EBM relayed through a total of ten organizational emails.

Table 1. Project Application of Kotter's 8-Step Change Model

Kotter's Principle	How achieved
Establish a sense of urgency	Web-based presentation; EBM and screening recommendations reviewed
Form a guiding coalition (GC)	Recruited 1 APP lead per clinic and division nurse manager
Create a vision	Improved patient satisfaction and outcomes
Communicate the vision	Nursing in-services; organizational EBM emails
Empower broad-based action	Providers supported with tools: NCCN and ASCO screening tool, EBM emails
Generate short-term wins	Value-based care metrics: successful implementation of screening tools
Consolidate gains and produce more gains	Relay of successful implementation; modifications of intervention if indicated
Anchor new approaches in the corporate culture	Integration of cardiac screening into organizational pathway

Note. Information from Kotter (1996).

Educational Intervention

The introductory phase of the project entailed a web-based PowerPoint presentation that was delivered by the project lead and detailed ANT-associated CTx in cancer patients with histories of breast cancer, lymphoma, and sarcoma. Content included topics pertinent to the project, such as the incidence of ANT-associated CTx, heart disease in cancer patients, proposed mechanisms of action of ANT-associated CTx, compounding cardiac risk factors, ECHO metrics as predictive measurements of late-onset CTx, and national guidelines for screening high cardiac risk patients. Approximately 15 attendees were on the call, an estimated seven of whom were providers. Remaining attendees included administrative and clinical leadership team members and the compliance officer.

Cardiac Screening Tool

The screening tool (Appendix A) was adapted from the ASCO guidelines for "Prevention and Monitoring of Cardiac Dysfunction in Survivors of Adult Cancers" (Armenian et al., 2016) and the NCCN guidelines (NCCN, 2019) and aimed to aid the providers in risk stratifying ANT-exposed patients into a low or high cardiac risk group. The tool was reviewed and summarized during the educational presentation. Providers were educated on the baseline characteristics used to risk stratify patients, including demographics, medical risk factors, lifestyle risk factors, and cardiotoxic cancer treatments; surveillance and monitoring

approaches for patients after completion of ANT therapies; and the EBM that supports these recommendations. Printed and virtual versions of the tool were distributed and posted in provider offices as reminders and easy references.

Evidence-Based Literature

To further enhance provider knowledge, evidence-based articles pertinent to the project were shared with participants via organizational emails every 2 weeks for a total of 10 emails. Article topics included the role of ECHOs in screening, cardiac risk factors, drug-specific CTx, prolonged QT interval, GLS, HTN and CTx, cancer survivorship and CTx, cardioprotective agents, the cost effectiveness of screening, and a summary email. References for all articles are in Appendix B.

Data Collection and Analysis

The project lead collected data from two sources: reports generated from the organization's electronic medical records (EMR) to gather data for the primary aim, and pre- and post-project provider surveys submitted via the online survey tool SurveyMonkey to gather data for the secondary aims. The reports identified medical record numbers (MRNs) of cancer patients over age 60 with histories of breast cancer, lymphoma, or sarcoma who were seen in follow-up by providers invited to participate in the project the month of the chart review and had been previously treated with an ANT between the years of 2016 and 2019. Reports were

generated at baseline, prior to project start, and at the end of each month of the project. The project lead performed 60 independent chart reviews from January 1, 2019, through October 2, 2019, and twenty independent chart reviews per month from October 3, 2019, through February 28, 2020, using qualifying MRNs to determine if an ECHO was performed following ANT treatment. Medical record numbers associated with post-treatment ECHOs were considered to be positive outcomes. At the end of the 5-month collection period, a run chart was generated comparing baseline and monthly data to establish the trend of the ECHOs performed or ordered in the post-ANT setting. The number of ECHOs performed of the 20 charts reviewed per month was converted into a percentage. Medical record numbers were deleted from the project database after the analysis was completed.

Pre- and post-project SurveyMonkey surveys were created by the project lead and were not validated tools. The majority of survey questions were identical for comparison of competencies and practice behaviors and posed questions requiring multiple-choice responses. Both gathered participant demographics, competencies, and practice behaviors, while the post-survey captured additional feedback from participants regarding their perspectives, experiences, barriers, and facilitators to the project (Appendices C and D). Each participant entered a personal identification number, which allowed for comparison of pre- and post-project survey answers. Inquiry regarding provider type (MD, APP) was not made due to project lead familiarity of the participants. Survey questions that assessed competencies were multiple choice and generated from evidence-based literature, and therefore were appropriate and meaningful. However, the reliability of the questions to accurately and consistently measure participant competencies could not be confirmed due to first-time use of survey questions, anonymity of the survey takers, and small sample size. Data were analyzed in IBM Statistical Package for the Social Sciences (SPSS) version 26. Frequencies of pre- and post-project survey variables were then compared. Descriptive statistics were used to analyze the data.

RESULTS

Approximately 12 providers in total completed pre- and post-project surveys, illustrating a 60%

response rate of the approximately 20 providers invited to participate. Most of the survey takers were female (93%) and 50% each a part-time or full-time employee. The majority of participants had 11 to 15 years of experience as a provider (50%) and in oncology (56.3%).

The primary aim of increasing the frequency of ECHOs performed in post-ANT exposed high cardiac risk patients by 25% was not met. Frequency was zero at baseline and for the first 2 months of the project. It increased to 20% in the third and fifth months of the project, illustrating an 80% primary aim attainment (Table 2). Collectively, ECHOs performed during or after treatment were ordered by 2 of the 12 participating providers, which equates to 17% of providers changing their practice as a result of the interventions. The data set was too small to calculate a level of significance or an effect size. Survey questions assessing secondary aims revealed 100% of providers feel screening and monitoring cancer patients for CTx are of value. The highest percentages of provider-reported patients screened weekly were 0 to 5 (58%) before the project and 6 to 10 (50%) afterward, demonstrating a greater number of patients screened each week after the intervention. The provider-perceived percentage of patients at high cardiac risk was 26% to 50% both before (50%) and after (70%) the project, illustrating a 20% increase in provider-perceived patients at risk. Competencies of ECHO measurements, identifying examples of high cardiac risk patients, and drug-specific CTx all remained relatively unchanged. The most common stated barriers to screening patients, reading EBM emails, or ordering post-ANT ECHOs were

Table 2. Frequency of Oncology Providers Ordering Post-Anthracycline Exposure Echocardiogram for High Cardiac Risk Cancer Patients With Histories of Breast Cancer, Lymphoma, and Sarcoma

Month	Percentage
Baseline	0%
1: October	0%
2: November	0%
3: December	20%
4: January	18.2%
5: February	20%

time constraints (90%), organizational constraints (60%), and systems issues (40%). Facilitating factors included personal desire to grow (100%), clinical project leaders (40%), project coordinator involvement and support (40%), and available resources (ASCO/NCCN guidelines, EBM emails; 20%). Face-to-face inquiries revealed additional barriers (Table 3).

DISCUSSION

The fields of cardiology and oncology collectively continue to expand a robust body of knowledge that supports the small but significant incidence of cancer treatment-associated CTx and the impact oncology providers can have on CV outcomes in cancer survivors. Findings of this project demonstrate an increased perception of patients at risk and reported number of patients screened. Still, despite reported value of cardiac screening of cancer patients, EBM, and national recommendations, the interventions did not improve competencies or markedly change practice. The EBM strongly supported the need to change practice but was not sufficient enough or delivered in such a manner for providers to consistently integrate these guidelines into practice. It is critical that providers gain a deeper understanding of the interplay between cardiac risk factors, CV risk profiles of cancer therapies, and CV changes that occur in patients with cancer, as it can impact cancer therapy delivery and long-term care (Minasian et al., 2020, p. 649).

One key project finding is the perceived value of the EBM without a notable change in behavior.

Though EBM justifies and drives clinical decision-making, it is largely underutilized so does not have the impact it potentially can on short- and long-term patient care (Kristensen et al., 2016). The literature states that integration of current research can take up to a decade to implement in clinical practice, which further accentuates the known gap between research and practice. This project attempted to bridge this gap by relying on providers' motivation to read EBM and apply it as indicated. This is a documented barrier to effective implementation of new research results in practice (p. 1). In addition methods similar to the interventions used in this project (emails, classroom teaching) have been described as "...ineffective in establishing new research-based practice as they solely raise awareness of the change, but fail to make it actionable..." (p. 8). Quality improvement is necessary to improve the outcomes of care, but disseminating and promoting integration into an environment with competing initiatives and constant change is often met with challenges unique to each setting.

Despite considerable efforts, two of the most critical components of successful implementation of change efforts described by Kotter were lacking (Kotter, 1996). A sense of urgency of the problem did not seem to develop among the stakeholders, and the Guiding Coalition was not strong enough to create and sustain the change effort. Surveys revealed competing organizational initiatives and individual priorities diverted provider attention thus lowering screening as a priority. Simultaneous and continuous organizational change initiatives are additive to the workload, consume time, compromise recall, and saturate internal and external resources thus leading to the phenomenon of *change fatigue* (Ead, 2015). A Guiding Coalition made up of strong leaders is needed to help prioritize change measures, identify barriers, such as change fatigue, support knowledge exchange, and create realistic approaches to implementation of change initiatives (Kotter, 1996).

This project illustrates the multifaceted challenges associated with implementing QI initiatives and, most importantly, those associated with changing behavior. The primary and secondary aims of this project were only partially met due to several limitations. Most notable are the many

Table 3. Barriers to Screening and Additional Comments (Number of Participants)

Overwhelmed with administrative and clinical responsibilities (4)
Schedules are too busy (7)
Challenging to balance responsibilities (5)
Low priority (1)
Forgot to screen (5)
New grads: Felt challenged with learning new skills and remembering to screen (4)
EMR embedded reminders to screen would be helpful (2)
Not cost effective (1)

responsibilities oncology providers are tasked with to provide the best patient care, including staying abreast of and implementing best practice guidelines; nurturing new providers; navigating through and meeting metrics of care in the constantly changing political and reimbursement systems; and supporting QI measures, all while juggling miscellaneous clinical and administrative duties. This project is one of many that illustrates our current model of care and additive demands to improve health-care outcomes tax the stakeholders and can thus stymie change efforts.

Limitations

Several contextual elements and limitations were noted after the project completion and included short project duration and timing of implementation; low provider attendance and involvement; unforeseen challenges related to implementation of a new version of the EMR system 1 month prior to the project start; increased provider workload; insufficient pre-project organizational assessment; limited and small amount of data collection; and surveys that did not gather adequate text to accurately capture provider experiences or the role change fatigue played in the implementation of the project.

Clinical Implications

The findings of this project have implications for change efforts in oncology and other health-care settings. These building blocks can serve as essential tools for implementing EBM into practice, which cultivate cultures of trust, transparency, and teamwork, thus creating platforms for sustainable implementation of change (Figure 1):

- Identify organizational and individual provider needs and priorities using validated tools.
- Tailor EBM-supported interventions to the learning needs and priorities of oncology providers.
- Establish teams of early adopters of change efforts to guide, motivate, and support stakeholders.
- Encourage development of APP-driven mentorship and fellowship programs for APPs new to oncology to strengthen fundamental skills and competencies.

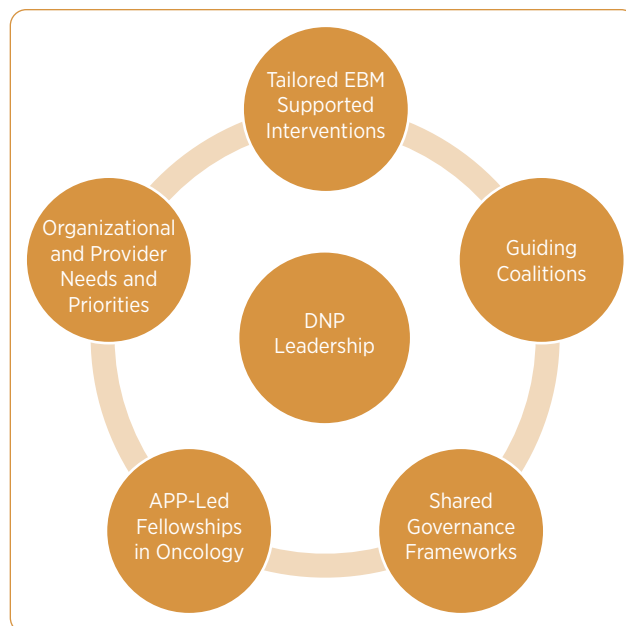


Figure 1. Implications for practice. DNP = Doctor of Nursing Practice; EBM = evidence-based medicine; APP = advanced practice provider.

- Promote development of shared governance frameworks within oncology settings to strengthen relationships between administrative and clinical stakeholders and boost collaborative change efforts.

CONCLUSIONS

The trajectory of cancer survivorship is affected by cardiovascular disease. Many cancer survivors harbor risk factors that increase the likelihood they will develop CTx if exposed to cardiotoxic agents. The literature strongly supports that if EBM for risk stratifying and screening of high cardiac risk patients exposed to ANTs is consistently applied, cancer treatment-associated cardiovascular disease can be prevented, mitigated, and/or managed at an earlier point on the disease spectrum. If statistical predictions are accurate, over the next 20 years, oncology providers will be treating and following an exponentially larger, older population of cancer survivors who carry this risk. Integrating evidence-based guidelines for cardiac screening into practice has the potential to positively impact the health outcomes of this susceptible population.

Each year, oncology providers are presented with new initiatives and practice recommendations to improve outcomes, which are additive to

the current workload (Ead, 2015). This chronicity of change in health-care settings can create instability and change fatigue in a culture, such that attempts should be made to address factors contributing to failed QI initiatives before implementation. This project had great purpose and heightened awareness of the need to change practice. Although more positive outcomes were desired, the project identified common barriers to change and necessary elements for implementing change initiatives. The long-term economic and population health gains of integrating CV screening into practice are potentially substantial. Yet, it is difficult for providers to see and make changes for a big picture impact with challenges immediately in front of them.

The web of complexities inherent to oncology care presents an incredible challenge for agents of change and health-care providers alike. The work of oncology providers can be daunting and exhaustive, but they return to the clinic day after day wanting to make a difference. And they do. The collective impact on outcomes of care occurs as oncology professionals each do their part by continuing to be open to, supportive of, and involved in efforts to improve the quality of oncology care. ●

Disclosure

The authors have no conflicts of interest to disclose.

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Appendix A. Cardiac Screening Tool

Baseline Assessment of Cardiovascular Risk Factors

Assess for cardiac risk factors

- ✓ Current myocardial disease
- ✓ Heart failure
- ✓ Asymptomatic LV dysfunction (LVEF < 50% or high natriuretic peptide)
- ✓ Coronary artery disease (previous myocardial infarction, angina, history of CABG)
- ✓ Hypertension
- ✓ Cardiomyopathy
- ✓ Significant cardiac arrhythmias (AF)

Demographics/Cardiac risk factors

- ✓ Age < 18 or > 50 for trastuzumab; > 65 for anthracyclines
- ✓ Diabetes
- ✓ Hypercholesterolemia
- ✓ Family history of premature CV disease
- ✓ Age ≥ 60 years at cancer treatment

Lifestyle risk factors

- ✓ Smoking
- ✓ Regular consumption of alcohol
- ✓ Low physical activity/exercise
- ✓ Sedentary habit
- ✓ Obesity

Cardiotoxic cancer treatment

- ✓ High-dose (≥ 250 mg/m²) or prior anthracycline use
- ✓ Low-dose anthracycline (< 250 mg/m²) + history of radiotherapy in heart field
- ✓ Trastuzumab + two or more risk factors
- ✓ High-dose (≥ 30 Gy) or prior radiotherapy to chest or mediastinum

Baseline Screening Recommendations

Baseline measurement of cardiac function

- ✓ Echocardiogram, multigated acquisition scan (anthracyclines, trastuzumab)
- ✓ Cardiac biomarkers (natriuretic peptides, troponins)

Note. AF = atrial fibrillation; CABG = coronary artery bypass graft; CAD = coronary artery disease; CV = cardiovascular; LV = left ventricular; LVEF = left ventricular ejection fraction; LVH = left ventricular hypertrophy; VT = ventricular tachycardia. Tool adapted from Armenian et al. (2016); NCCN (2019).

Appendix B. References of Articles Shared in Evidence-Based Literature Emails

Week #1: The Role of Echocardiograms


Liu, J., Banchs, J., Mousavi, N., Plana, J. C., Scherrer-Crosbie, M., Thavendiranathan, P., & Barac, A. (2018). Contemporary role of echocardiography for clinical decision making in patients during and after cancer therapy. *JACC: Cardiovascular Imaging*, 11(8), 1122–1131. <https://doi.org/10.1016/j.jcmg.2018.03.025>

Week #2: Comorbidities and Cardiotoxicities

Kosalka, P., Johnson, C., Turek, M., Sulpher, J., Law, A., Botros, J.,...Aseyev, O. (2019). Effect of obesity, dyslipidemia, and diabetes on trastuzumab-related cardiotoxicity in breast cancer. *Current Oncology*, 26(3), e314–e321. <https://doi.org/10.3747/co.26.4823>

Week #3: Drug-Specific Cardiotoxicities

Babak, S., & Brezden-Masley, C. (2018). Cardiovascular sequelae of breast cancer treatments: A review. *Current Problems in Cancer*, 42(4), 409–421. <https://doi.org/10.1016/j.currproblcancer.2018.06.009>

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Appendix B. References of Articles Shared in Evidence-Based Literature Emails (cont.)**Week #4: QT Intervals (physician-requested topic)**

Muluneh, B. et al (2019). Trials and tribulations of corrected QT interval monitoring in oncology: Rationale for a practice-changing standardized approach. *Journal of Clinical Oncology*, 37(30), 2719–2721. <https://doi.org/10.1200/JCO.19.00922>

Week #5: Global Longitudinal Strain

Avalyan, A., Kirillova, M., Shitov, V., Saidova, M., Stenina, M., Oshchepkova, E., & Chazova, I. (2017). [PP.24.18] Global longitudinal strain as marker of cardiotoxicity in patients with triple negative breast cancer with or without arterial hypertension. *Journal of Hypertension*, 35, e292. <https://doi.org/10.1097/01.hjh.0000523854.93956.20>

Cherata, D. A., Rodriguez-Zanella, H., Riccoboni, D., Palermo, C., Muraru, D., Aruta, P.,...Badano, L. P. (2017). P160 Three-dimensional left ventricular global longitudinal strain is as feasible and accurate as two-dimensional global longitudinal strain for subclinical cardiotoxicity surveillance. *European Heart Journal*, 38(suppl_1) <https://doi.org/10.1093/eurheartj/ehx501.P160>

Gripp, E. d. A., Oliveira, G. E. d., Feijó, L. A., Garcia, M. I., Xavier, S. S., & Sousa, A. S. d. (2018). Global longitudinal strain accuracy for cardiotoxicity prediction in a cohort of breast cancer patients during anthracycline and/or trastuzumab treatment. *Arquivos Brasileiros De Cardiologia*, 110(2), 140–150. <https://doi.org/10.5935/abc.20180021>

Levis, M., De Luca, V., Bartoncini, S., Botto, B., Giorgi, M., Chiappella, A.,...Ricardi, U. (2018). A prospective, observational study evaluating early subclinical cardiotoxicity with global longitudinal strain imaging in lymphoma patients treated with chemotherapy +/- mediastinal radiation therapy: The CARDIOCARE project. *International Journal of Radiation Oncology, Biology, Physics*, 102(3), S88–S88. <https://doi.org/10.1016/j.ijrobp.2018.06.230>

Mornos, C., & Petrescu, L. (2013). Early detection of anthracycline-mediated cardiotoxicity: The value of considering both global longitudinal left ventricular strain and twist. *Canadian Journal of Physiology and Pharmacology*, 91(8), 601–607. <https://doi.org/10.1139/cjpp-2012-0398>

Week #6: Hypertension and Cardiotoxicities

Hershman, D. L., McBride, R. B., Eisenberger, A., Tsai, W. Y., Grann, V. R., & Jacobson, J. S. (2008). Doxorubicin, cardiac risk factors, and cardiac toxicity in elderly patients with diffuse B-cell non-Hodgkin's lymphoma. *Journal of Clinical Oncology*, 26(19), 3159–3165. <https://doi.org/10.1200/jco.2007.14.1242>

Hequet, O., Le, Q. H., Moullet, I., Pauli, E., Salles, G., Espinouse, D.,...Coiffier, B. (2004). Subclinical late cardiomyopathy after doxorubicin therapy for lymphoma in adults. *Journal of Clinical Oncology*, 22(10), 1864–1871. <https://doi.org/10.1200/JCO.2004.06.033>

Kuriakose, R. K., Kukreja, R. C., & Xi, L. (2016). Potential therapeutic strategies for hypertension-exacerbated cardiotoxicity of anticancer drugs. *Oxidative Medicine and Cellular Longevity*, 2016, 8139861. <https://doi.org/10.1155/2016/8139861>

Jain, M., & Townsend, R. R. (2007). Chemotherapy agents and hypertension: A focus on angiogenesis blockade. *Current Hypertension Reports*, 9(4), 320–328. <https://doi.org/10.1007/s11906-007-0058-7>

Pinder, M. C., Duan, Z., Goodwin, J. S., Hortobagyi, G. N., & Giordano, S. H. (2007). Congestive heart failure in older women treated with adjuvant anthracycline chemotherapy for breast cancer. *Journal of Clinical Oncology*, 25(25), 3808–3815. <https://doi.org/10.1200/JCO.2006.10.4976>

Week #7: Cancer Survivorship

Harrison, J., Friese, C., Barton, D., Janz, N., Pressler, S., & Davis, M. (2018). Heart failure and long-term survival among older women with breast cancer. *Oncology Nursing Forum*, 45(1), 77–87. <https://doi.org/10.1188/18.ONF.77-87>

Strongman, H., Gadd, S., Matthews, A., Mansfield, K. E., Stanway, S., Lyon, A. R.,...Bhaskaran, K. (2019). Medium and long-term risks of specific cardiovascular diseases in survivors of 20 adult cancers: A population-based cohort study using multiple linked UK electronic health records databases. *Lancet*, 394(10203), 1041–1054. [https://doi.org/10.1016/S0140-6736\(19\)31674-5](https://doi.org/10.1016/S0140-6736(19)31674-5)

Week #8: Carvedilol and Anthracycline-Associated Cardiotoxicities

Kheiri, B., Abdalla, A., Osman, K., Osman, M., Haykal, T., Chahine, A.,...Bhatt, D. L. (2018). Meta-analysis of carvedilol for the prevention of anthracycline-induced cardiotoxicity. *American Journal of Cardiology*, 122(11), 1959–1964. <https://doi.org/10.1016/j.amjcard.2018.08.039>

Week #9: Cost-Effectiveness of Screening

Yu, A., Yin, A., Liu, J., & Steingart, R. M. (2017). Cost-effectiveness of cardiotoxicity monitoring. <https://www.acc.org/latest-in-cardiology/articles/2017/08/14/07/23/cost-effectiveness-of-cardiotoxicity-monitoring>


Nolan, M. T., Plana, J. C., Thavandiranathan, P., Shaw, L., Si, L., & Marwick, T. H. (2016). Cost-effectiveness of strain-targeted cardioprotection for prevention of chemotherapy-induced cardiotoxicity. *International Journal of Cardiology*, 212, 336–345. <https://doi.org/10.1016/j.ijcard.2016.02.137>

Week #10: Cardio-Oncology Summary

Koutsoukis, A., Ntalianis, A., Repasos, E., Kastritis, E., Dimopoulos, M., & Paraskevidis, I. (2018). Cardio-oncology: A focus on cardiotoxicity. *European Cardiology*, 13(1), 64–69. <https://doi.org/10.15420/ecr.2017:17:2>

Appendix C. Pre-Project Survey

1. Age
 - a. 20-30
 - b. 31-40
 - c. 41-50
 - d. 50+
2. Gender
 - a. Male
 - b. Female
3. Years in practice
 - a. 1-5
 - b. 6-10
 - c. 11-15
 - d. 16+
4. Years practicing in oncology
 - a. 1-5
 - b. 6-10
 - c. 11-15
 - d. 16+
5. Work status
 - a. Full-time
 - b. Part-time
6. Do you feel it is important to screen and/or monitor cancer patients for cardiotoxicities (CTx)?
 - a. Yes
 - b. No
7. What percentage of your patients do you think are at high risk of developing CTx?
 - a. 0%-25%
 - b. 26%-50%
 - c. 51%-75%
 - d. 76%-100%
8. On a weekly basis, how many patients do you assess or screen for CTx (i.e., review family history of congestive heart failure [CHF], heart failure; review medical history for CHF, hypertension, hypercholesterolemia, diabetes, smoking status, age of exposure to cardiotoxic therapies; order radiologic screening for new or concerning sign or symptom or concern for high-risk status)?
 - a. 0-5
 - b. 6-10
 - c. 11-15
 - d. 15+
9. How often do you order echocardiograms for cancer patients who have been prescribed an anthracycline *before* exposure?
 - a. I never order echocardiograms before exposure
 - b. I sometimes order echocardiograms before exposure (if patient is symptomatic)
 - c. I always/routinely order screening echocardiograms before exposure
10. How often do you order echocardiograms for cancer patients who have been prescribed an anthracycline *during* exposure?
 - a. I never order echocardiograms during exposure
 - b. I sometimes order echocardiograms during exposure (if patient is symptomatic)
 - c. I always/routinely order screening echocardiograms during exposure
11. How often do you order echocardiograms for cancer patients who have been prescribed an anthracycline *after* exposure?
 - a. I never order echocardiograms after exposure
 - b. I sometimes order echocardiograms after exposure (if patient is symptomatic)
 - c. I always/routinely order screening echocardiograms after exposure

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Appendix C. Pre-Project Survey (cont.)

12. Which of the following have a known risk of CTx? Select all that apply:
- Doxorubicin
 - Fluorouracil (5-FU)/capecitabine
 - Trastuzumab
 - Liposomal doxorubicin
 - Anastrozole
13. Which of the following illustrates risk of acute or late-onset CTx? Select all that apply:
- A change in global longitudinal strain from -19.9% to -13.1%
 - A change in left ventricular ejection fraction from 62% to 54%
 - A change in global longitudinal strain from -17.0% to -20.3%
 - A change in left ventricular ejection fraction from 65% to 49%
14. Which of the following resources drive how you screen/monitor cancer patients at risk for cancer treatment-associated CTx? Select all that apply:
- Drug manufacturer's product information sheet
 - Familiarity with "at risk" agents
 - I follow another provider's recommendations
 - National guidelines
 - Patient symptoms and/or medical history
 - Published recommendations
15. Which cancer patient is considered high risk for developing cancer treatment-induced CTx? Select all that apply:
- A 49-year-old woman with a history of HER2/neu-amplified left breast cancer, currently being treated with chemotherapy with dose-dense doxorubicin/cyclophosphamide, paclitaxel/trastuzumab
 - A non-smoking, healthy 71-year-old man with a history of non-Hodgkin lymphoma diagnosed at the age of 60 and treated with rituximab, cyclophosphamide, doxorubicin, and prednisone
 - A 56-year-old male with a history of stage III colon cancer actively being treated with FOLFOX chemotherapy
 - An 85-year-old healthy woman with a history of stage I breast cancer, status post lumpectomy, left-sided radiation, and 5 years of tamoxifen
 - A 22-year-old male with a history of a soft tissue sarcoma currently being treated with doxorubicin, ifosfamide, and mesna
16. What influences you to change your practice?
- Evidence-based medicine
 - Organizational policy change
 - It comes from within—if I think it is important, I will change without external influence
 - I need to see others change before I do

Appendix D. Additional Post-Project Survey Questions

1. Over the course of the project, ten (10) emails were sent to you sharing evidence-based medicine (EBM)/literature pertaining to cardio-oncology topics. How many did you read?
2. If you did not read any or many EBM emails, what is the main reason?
 - a. I received too many emails
 - b. The information was not pertinent to my practice
 - c. I did not have time to read the emails
 - d. Other
3. If any, which of the EBM topics did you find helpful? Select all that apply:
 - a. Role of echocardiograms in screening
 - b. Compounding factors for cardiotoxicities: obesity, dyslipidemia, diabetes
 - c. Drug-specific cardiotoxicities
 - d. QT interval
 - e. Global longitudinal strain
 - f. Hypertension and cardiotoxicities
 - g. Cancer survivorship
 - h. Cardioprotective strategies
 - i. Cost-effectiveness of screening
 - j. Cardio-oncology summary
4. Which of the following were barriers to utilization of the screening tool? Select all that apply:
 - a. Organizational constraints
 - b. Systems issues (i.e., implementation of EMR system, staffing shortage)
 - c. Time constraints
 - d. Dissatisfaction with project or screening tool
 - e. Disinterest in project or screening tool
 - f. Project and/or tool were not valuable to me
 - g. I am not interested in changing my screening practices
 - h. Other
5. Which of the following were facilitators of the project tools?
 - a. Project coordinator involvement & support
 - b. Available resources (ASCO/NCCN guidelines, EBM email support tools)
 - c. Clinical project leaders
 - d. Communication with other oncology providers
 - e. Personal desire to grow & improve my practice
6. What suggestions do you have to improve the project or interventions?