Radiation Physics Center 2023 Report

A report from the Childhood Cancer Survivor Study

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MD Anderson Cancer Center
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Childhood Cancer Survivor Study

Radiation Physics Center Team

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- Our team has a well-established decades long collaboration with CCSS
  - Includes medical physicists and dosimetrists, research data coordinators, computational scientists and programmers, physics technicians, graduate students, and administrative staff

Roles of the Radiation Physics Center

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- Provide input during proposal development regarding level of dosimetry detail needed and/or achievable for planned analyses
- Maintain secure database with scanned indexed copies of the complete radiation therapy (RT) records from CCSS institutions
- Calculate organ and body-region doses from RT for study participants
- Assist the investigators in understanding and using the RT data in analyses and manuscripts

Radiation Dosimetry Process

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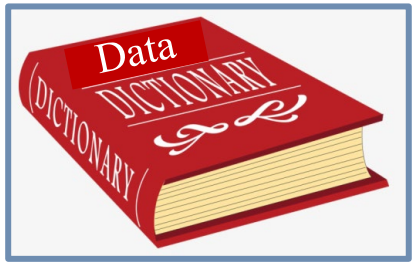
1. Abstract patients' RT records **CCSS: N > 13,000**
2. Reconstruct RT fields on in-house phantom scaled to age at RT
3. Calculate dose to region or organ of interest
4. Quality assurance of computed doses
5. Create output files and documentation (data dictionary)
6. Provide data to FH statistics center for distribution to individual investigators (with approved concept proposals)



Dose Reconstruction Methodology

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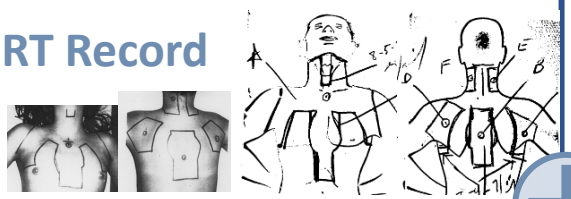
For EACH Individual in a Cohort

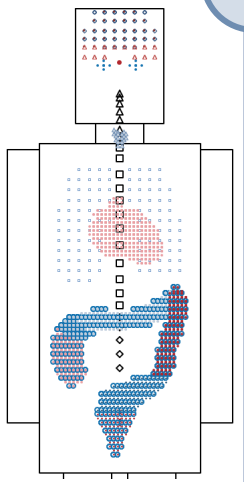
CCSS: N_{RT} > 13K

RT Record

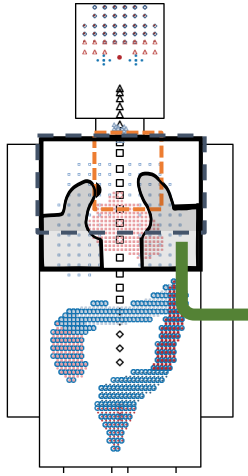


Abstract Historic Record:
DOB, RT dates, Rx(s), field parameters + location

- In-house computational phantom scaled to individual's age at RT



- Create personalized reconstructed composite plan



Organ doses & dose-volume metrics

Dosimetry methods described in Howell et al. Radiat Res. **2019.** 192(2):169-188
Phantom and organ scaling described in Gupta *et al.* Biomed. Phys. Eng. Express. **2020** 6(6):2057-1976

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In Progress and Completed CCSS Dosimetry

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Completed Organ/Region Dosimetry	Data Reported
Body regions + brain 4 segment	MaxTD, SH, SL
eyes/lenses*	D_m
Kidneys (right and left)	D_m
Lungs†*	D_m
Ovaries (right and left)	D_m
Pancreas (whole)*	D_m V_{20}, V_{30}
Pancreas (head, body, tail)*	D_m
Pituitary*	D_m
Testes	D_m
Uterus	D_m
Thyroid(right and left), *update in progress, expected 8/2023*	D_m
Heart (aorta, arteries, valves, ventricles)	D_m, V_5, V_{20}
Colorectum (ascending, descending, transverse, rectum)	D_m, V_5, V_{10}, V_{20}, V_{30}

*RT records for three institutions were received more recently.

We are systematically updating organ dosimetry

Maximum target dose (maxTD), stray high (SH), stray low (SL), Mean dose (D_m), percent volume ≥ 5 Gy (V_5), ≥ 20 Gy (V_{20}) and ≥ 30 Gy (V_{30})

†*More sophisticated organ modeling is needed*

Cardiac Research Update

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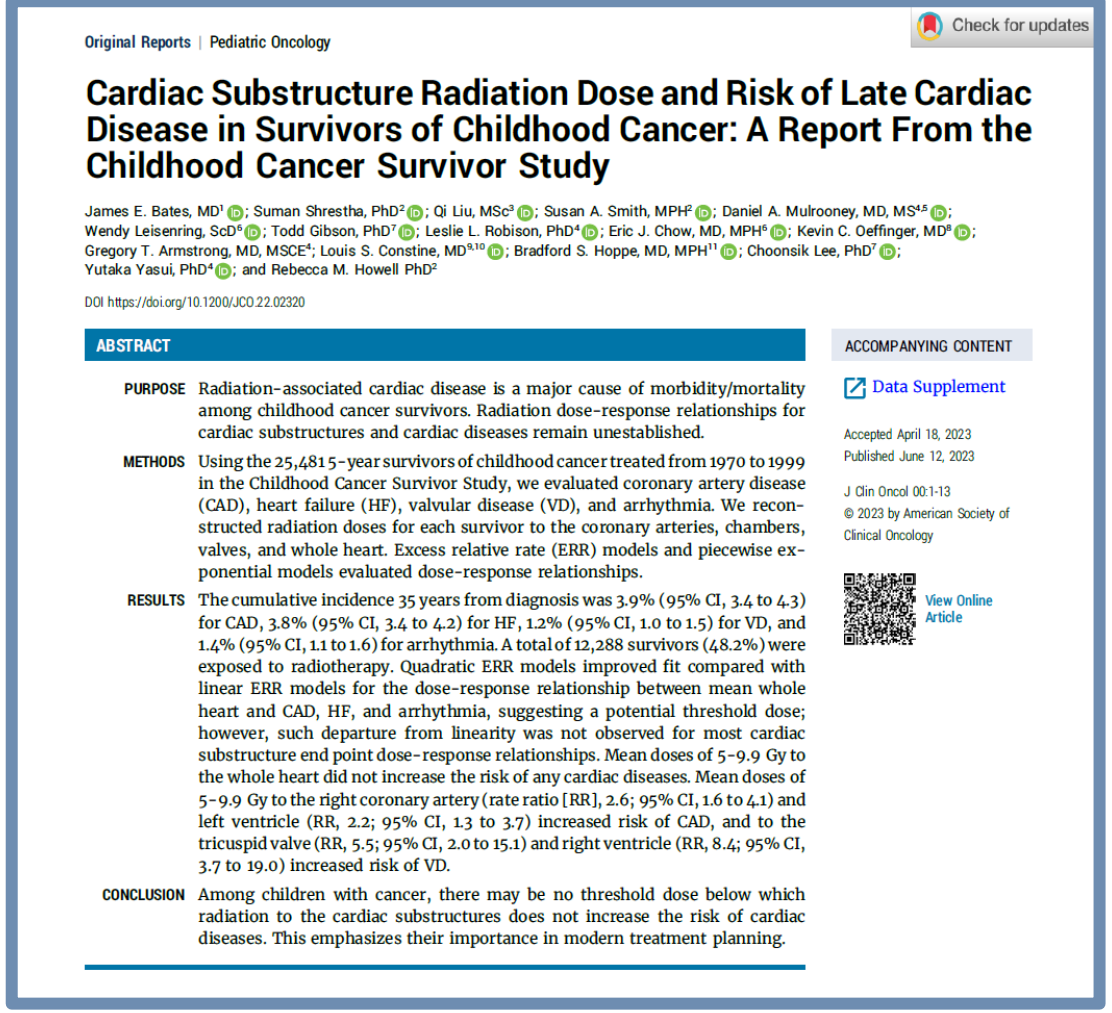
2023 Publication



Original Reports | Pediatric Oncology

Check for updates

Cardiac Substructure Radiation Dose and Risk of Late Cardiac Disease in Survivors of Childhood Cancer: A Report From the Childhood Cancer Survivor Study

James E. Bates, MD[1]; Suman Shrestha, PhD[2]; Qi Liu, MSc[3]; Susan A. Smith, MPH[2]; Daniel A. Mulrooney, MD, MS[4,5]; Wendy Leisenring, ScD[6]; Todd Gibson, PhD[7]; Leslie L. Robison, PhD[4]; Eric J. Chow, MD, MPH[6]; Kevin C. Oeffinger, MD[8]; Gregory T. Armstrong, MD, MSCE[4]; Louis S. Constine, MD[9,10]; Bradford S. Hoppe, MD, MPH[11]; Choonsik Lee, PhD[7]; Yutaka Yasui, PhD[4]; and Rebecca M. Howell PhD[2]

DOI https://doi.org/10.1200/JCO.22.02320

ABSTRACT

PURPOSE Radiation-associated cardiac disease is a major cause of morbidity/mortality among childhood cancer survivors. Radiation dose-response relationships for cardiac substructures and cardiac diseases remain unestablished.

METHODS Using the 25,481 5-year survivors of childhood cancer treated from 1970 to 1999 in the Childhood Cancer Survivor Study, we evaluated coronary artery disease (CAD), heart failure (HF), valvular disease (VD), and arrhythmia. We reconstructed radiation doses for each survivor to the coronary arteries, chambers, valves, and whole heart. Excess relative rate (ERR) models and piecewise exponential models evaluated dose-response relationships.

RESULTS The cumulative incidence 35 years from diagnosis was 3.9% (95% CI, 3.4 to 4.3) for CAD, 3.8% (95% CI, 3.4 to 4.2) for HF, 1.2% (95% CI, 1.0 to 1.5) for VD, and 1.4% (95% CI, 1.1 to 1.6) for arrhythmia. A total of 12,288 survivors (48.2%) were exposed to radiotherapy. Quadratic ERR models improved fit compared with linear ERR models for the dose-response relationship between mean whole heart and CAD, HF, and arrhythmia, suggesting a potential threshold dose; however, such departure from linearity was not observed for most cardiac substructure end point dose-response relationships. Mean doses of 5-9.9 Gy to the whole heart did not increase the risk of any cardiac diseases. Mean doses of 5-9.9 Gy to the right coronary artery (rate ratio [RR], 2.6; 95% CI, 1.6 to 4.1) and left ventricle (RR, 2.2; 95% CI, 1.3 to 3.7) increased risk of CAD, and to the tricuspid valve (RR, 5.5; 95% CI, 2.0 to 15.1) and right ventricle (RR, 8.4; 95% CI, 3.7 to 19.0) increased risk of VD.

CONCLUSION Among children with cancer, there may be no threshold dose below which radiation to the cardiac substructures does not increase the risk of cardiac diseases. This emphasizes their importance in modern treatment planning.

ACCOMPANYING CONTENT

Data Supplement

Accepted April 18, 2023
Published June 12, 2023

J Clin Oncol 00:1-13

View Online Article

R01 Funded Research

- Development, validation, and clinical translation of cardiac substructure level cardiac disease risk prediction models

Howell, Mulrooney, Yasui. Personalized Risk Prediction to Reduce Cardiovascular Disease in Childhood Cancer Survivors. 1R01CA261750-01A1

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Contemporary Radiotherapy

Radiotherapy Evolution – Hodgkin Lymphoma

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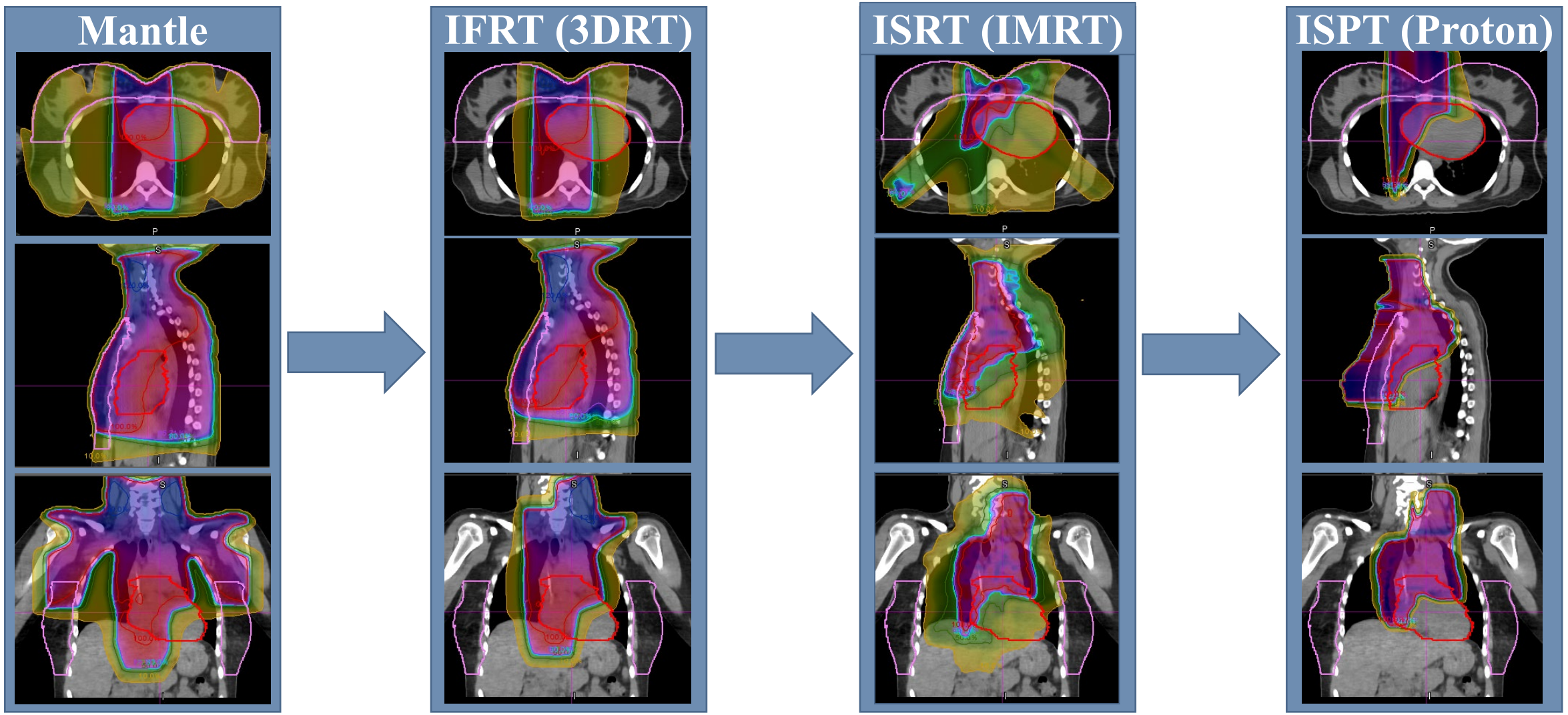

Slide adapted from Brad Hoppe, The Mayo Clinic – Jacksonville

Radiotherapy Evolution - CSI

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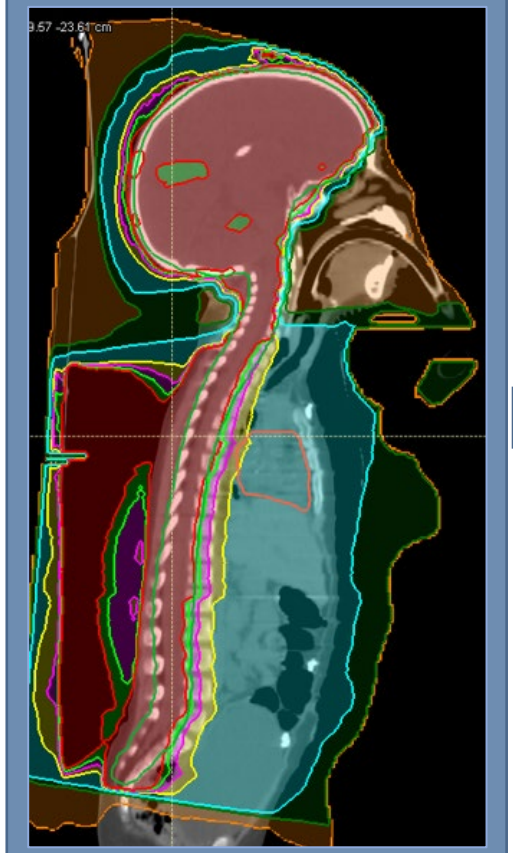
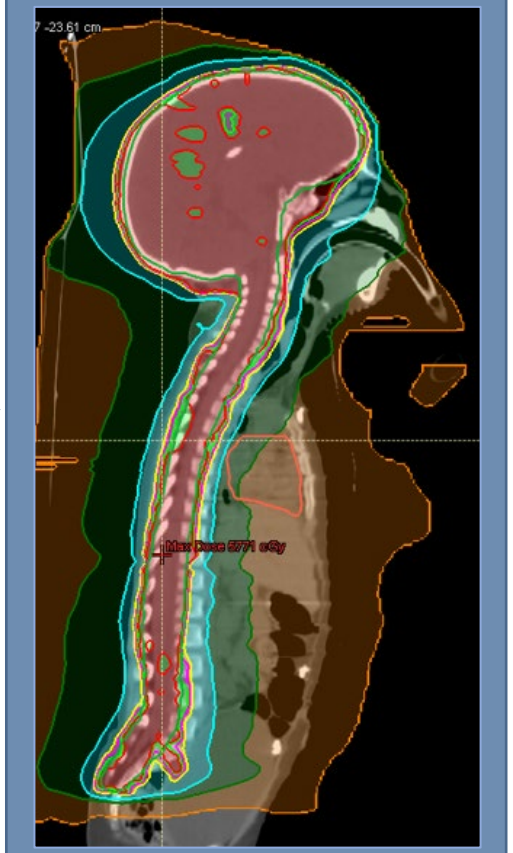
3DCRT



D_m - 21.4 Gy

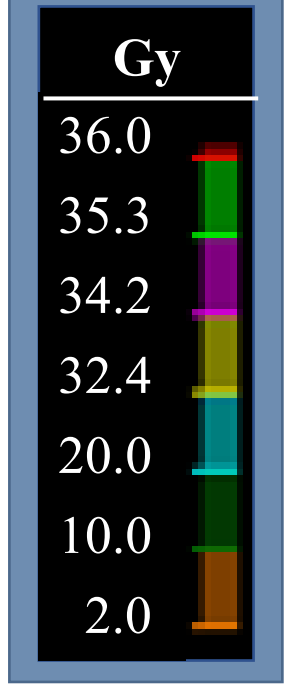
VMAT



D_m - 7.4 Gy (V_5>50%)

Proton

D_m – 0.02 Gy



Slide adapted from Dan Indelicato, University of Florida

Contemporary RT Workflow

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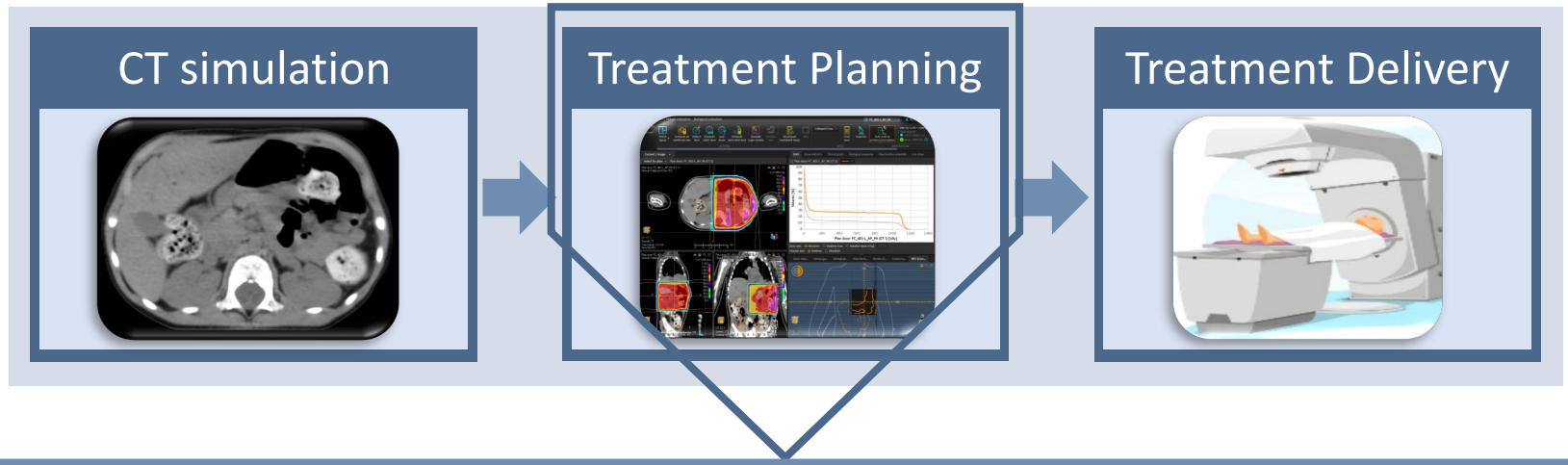

Patients' treatment plan data are stored in **Digital Imaging and Communications in Medicine (DICOM)** format, which is a standard protocol for the management and transmission of medical images and related data.

DICOM is the international standard to communicate and manage medical images and data. Its mission is to ensure the interoperability of systems used to produce, store, share, display, send, query, process, retrieve and print medical images.

4. **RT Dose:** Contains dose data generated by a treatment planning system in one or more of several formats: three-dimensional dose data, isodose curves, DVHs, or dose points.

Contemporary RT Pilot Study

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- Pilot study to assess the feasibility of collecting multi-institutional, multi-modality contemporary radiotherapy data and generation of organ- and body region dosimetry for childhood cancer survivors treated between 2000 and 2022, and evaluation of comparability to existing Childhood Cancer Survivor Study (CCSS) dosimetry data (1970-1999)

5 institutions + 2 additional data sources

5 CCSS pilot study institutions:

- MD Anderson Cancer Center
- Seattle Children's Hospital
- Children's Hospital of Philadelphia
- Emory Winship Cancer Institute
- St. Jude Children's Research Hospital

Imaging & Radiation Oncology Core (IROC)

- DICOM files previously archived by Children's Oncology Group (COG) into IROC-Rhode Island database.
- We estimate that ~ ⅓ - ½ of 500 RT records will be available through the IROC data archive.
- Each of the participating institutions submitted DICOM data to the COG for all individuals treated with RT and enrolled in COG clinical trials starting in 2012 and later.
- Thus, rather than requesting that the pilot study institutions to resubmit data for these individuals, we will work to directly acquire copies from IROC.

Proton RT Database(s)

- DICOM files previously collected for ~ ½ proton RT delivered since 2007 have been collected through efforts by Pediatric Proton/Photon Consortium Registry (PPCR – Harvard Torunn Yock) and NCI-REB
- We are exploring a collaboration to access these data

Pilot Study DICOM Data Collection
Explore Two Upload Methods

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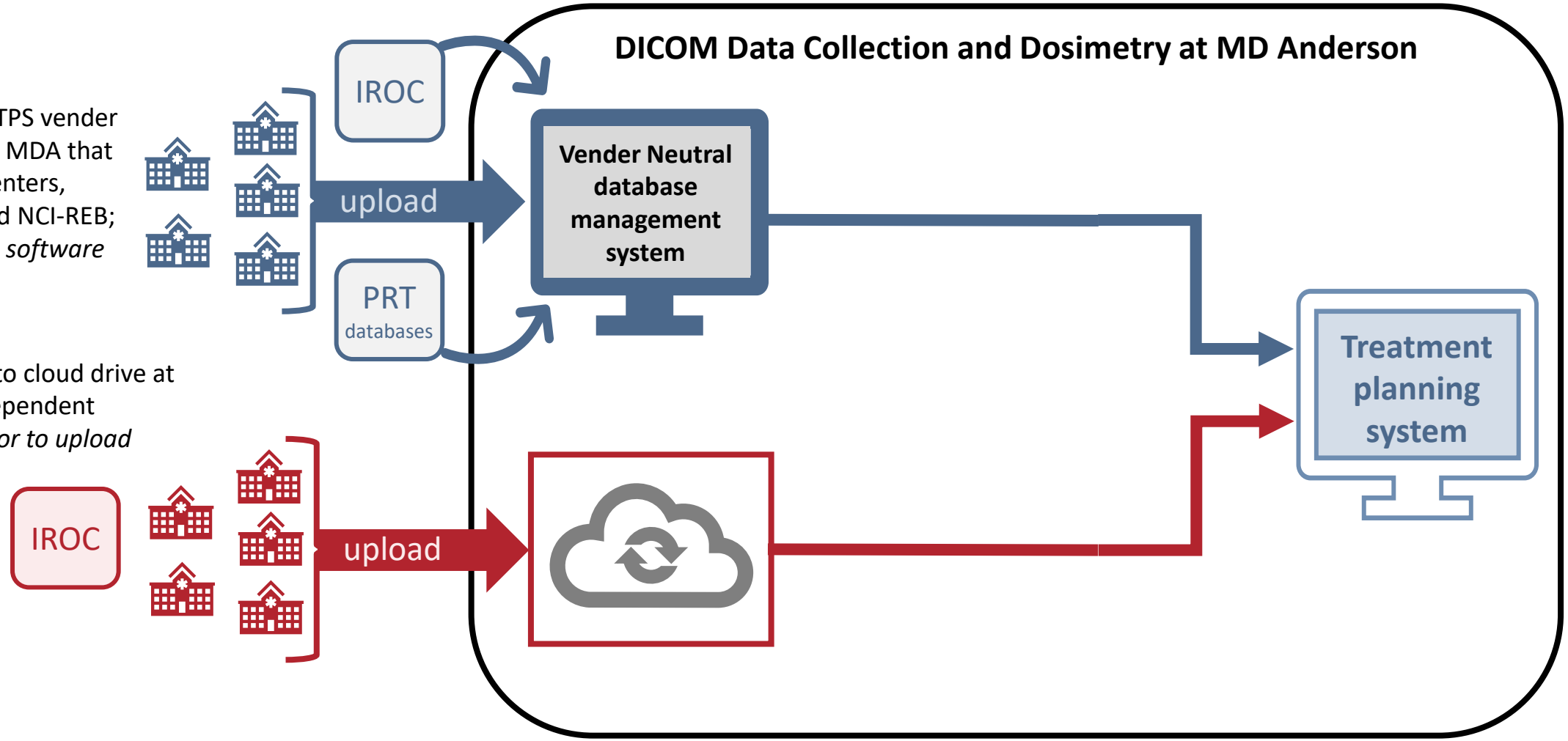
1. Data uploaded via TPS vender neutral software at MDA that is in use at many centers, PPCR (Harvard), and NCI-REB; d*eidentification via software at time of upload*

2. Data uploaded via to cloud drive at MDA; requires independent d*eidentification prior to upload*



Childhood Cancer Survivor Study

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- The Childhood Cancer Survivor Study is an NCI-funded resource (U24 CA55727) to promote and facilitate research among long-term survivors of cancer diagnosed during childhood and adolescence.

- Investigators interested in potential uses of this resource are encouraged to visit:

http://ccss.stjude.org


Thank You