Phantom FDA

Summary

Redirection Notice

This page will redirect to https://www.cancerimagingarchive.net/collection/phantom-fda/ in about 5 seconds.

As part of a more general effort to probe the interrelated factors impacting the accuracy and precision of lung nodule size estimation, we have been conducting phantom CT studies with an anthropomorphic thoracic phantom containing a vasculature insert on which synthetic nodules were inserted or attached.

The utilization of synthetic nodules with known truth regarding size and location allows for bias and variance analysis, enabled by the acquisition of repeat CT scans. Using a factorial approach to probe imaging parameters (acquisition and reconstruction) and nodule characteristics (size, density, shape, location), ten repeat scans have been collected for each protocol and nodule layout. The resulting database of CT scans is incrementally becoming available to the public via *The Cancer Imaging Archive* (TCIA) to facilitate the assessment of lung nodule size estimation methodologies and the development of image analysis software among other possible applications.

Data Access

Data Access

Data Type	Download all or Query/Filter	License
Images (DICOM, 728.5 GB)	*Download* *Search* (Download requires the NBIA Data Retriever)	CC BY 3.0
DICOM Metadata Digest (CSV, 862 kB)	*Download*	CC BY 3.0

Click the Versions tab for more info about data releases.

Additional Resources for this Dataset

The NCI Cancer Research Data Commons (CRDC) provides access to additional data and a cloud-based data science infrastructure that connects data sets with analytics tools to allow users to share, integrate, analyze, and visualize cancer research data.

- Imaging Data Commons (IDC) (Imaging Data)

Detailed Description

Detailed Description

Collection Statistics	
Modalities	CT
Number of Participants	7

Number of Studies	76
Number of Series	4,433
Number of Images	1,468,751
Image Size (GB)	728.5

Database Description (link)

The anthropomorphic thoracic phantom (Kyotokagaku Incorporated, Tokyo, Japan) employed in this study is shown in Figure 1, along with the vasculature insert on which synthetic nodules were attached before CT imaging. The phantom does not contain lung parenchyma so the space within the vascular structure is filled with air.

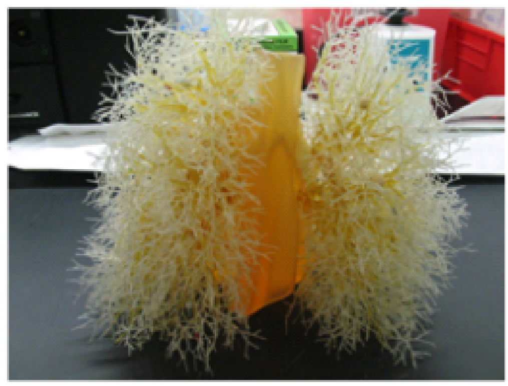


Fig 1: Photograph of the exterior shell of the thoracic phantom (left) and the vasculature insert (right).

The synthetic lung nodules used in our data CT scans were manufactured by either Kyotokagaku Incorporated (Japan) and Computerized Imaging Reference Systems (CIRS, Norfolk, VA). They consisted of objects varying in size (5, 8, 10, 12, 20, 40 mm), shape (spherical, elliptical, lobulated, spiculated), and density (-800, -630, -10, +100 HU). Figure 2 shows examples of the various sizes and shapes of synthetic nodules used in our CT data collection.

Eight different layouts of nodules were specified by placing them in premarked positions within the phantom vasculature, where they were either attached to vessels or suspended in foam (non-attached configuration). Care was taken to maintain constant positioning of the nodules when a particular layout was scanned multiple times or with different protocols. For that purpose, vessels on which nodules were attached were color coded. Table 1 tabulates the nodule configuration for the nodule layouts that are currently available at NBIA DICOM Radiology Portal in terms of nodule positioning, size, shape, and density. Figures 3-6 show a schematic diagram of the currently available layouts. All tables and figures in this document will be updated as more data is posted.

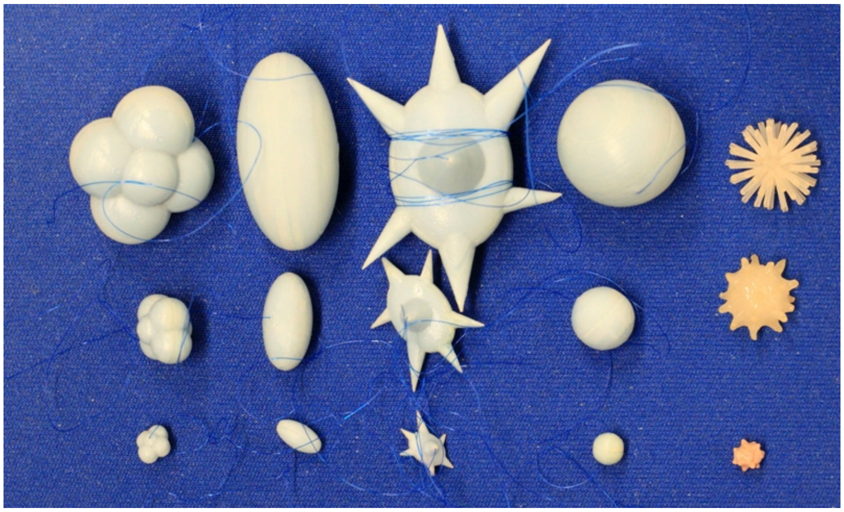


Figure 2: Photographs of the different types of synthetic nodules used in this study. Each column shows example nodules in three sizes, with *lobulated*, *elliptical*, *spiculated*, *spherical*, and *irregular* nodules shown from left to right. The three sizes shown here were manufactured to have the equivalent volumes of spherical nodules with diameters of 5, 10, and 20 mm (with the exception of the *irregular* shapes which have nominal diameters of about 5, 10, 12 mm). Additional nodules used in this study span the size range between 5-60mm.

Nodule layout	**Vessel attachment**	**Nodule placement and description**					
		Left lung			**Right lung**		
		Nominal diameter (mm)	*Shape**	*HU*	*Nominal diameter (mm)*	*Shape*	*HU*
1	attached	5,8,10	SPH	-800	5,8,10	SPH	-630
2	attached	5,8,10	SPH	100	8,12,15	irregular	-300, 30,30
3	attached	5,8,10,20,40	SPH	100	5,8,10,20,40	SPH	-630
4	attached	10, 20, 10, 20, 10, 20	ELL, ELL, LOB, LOB, SPI, SPI	-630	10, 20, 10, 20, 10, 20	ELL^, ELL, LOB, LOB, SPI, SPI	100

Table 1. Summary of currently available nodule layouts. *SPH- spherical, ELL- elliptical, LOB- lobulated, SPI-spiculated. ^Note: The 10mm, 100HU elliptical nodule in the right lung has a large hole in it. A replacement was scanned as part of Nodule 6 which will be released by the end of 2014.

The phantom was scanned using a Philips 16-row scanner (Mx8000 IDT, Philips Healthcare, Andover, MA) and a Siemens 64-row scanner (Somatom Definition 64, Siemens Medical Solutions USA, Inc., Malvern, PA). Scans were acquired with varying combinations of effective dose, pitch, and slice collimation, and were reconstructed with varying combinations of slice thicknesses and reconstruction kernels. Ten exposures were acquired for each imaging protocol. The phantom position was not changed during the 10 repeat exposures; however it was repositioned between different imaging protocols or different nodule layouts. **Table 2** summarizes the imaging protocols for the nodule layout.

NOTE: Each study in the database contains 10 repeat scans for that particular acquisition protocol, multiplied by the number of reconstructions. The study and series descriptions contain the following information:

Study description:

Contains information on: the *scanner vendor* (currently Philips or Siemens), the *exposure* (in mAs), the *pitch* (currently either 1.2 or 0.9 according to the definition , where *d* is the patient table travel in the horizontal direction and *T* is the detector width at the isocenter plane), and *slice collimation* (in mm).

Series description:

Contains information on *reconstructed slice thickness* (in mm), *reconstructed slice increment* (in mm), *and reconstruction filter or kernel* (currently either C for detail, or B for medium).

Nodule Layout, Scanner	**Eff.dose (mAs)**	**Slice collimation (mm)**	**Slice overlap**	**Pitch**	**Recon. Slice thickness (mm)**	**Recon. Kernels**	**# sets**
1,S1	20,50,100, 200	16x0.75, (16x1.5)	50%	0.9,1.2	0.75,1.5,3 (2,3,5)	C	**480**
2, S1	20,100,200	16x0.75, (16x1.5)	50%	0.9,1.2	0.75,1.5,3 (2,3,5)	C, B	**720**
3, S2	25, 100, 200	64x0.6	0%, 50%	0.9, 1.2	0.75, 1.5, 3.0	B40f, B60f	**720**
4, S1	25, 100, 200	16x0.75, (16x1.5)	50%	0.9,1.2	0.75,1.5,3 (2,3,5)	C, B	**720**
TOTAL							**2640**

Table 2. Summary of reconstructed CT datasets: a description of the individual nodule layouts are provided in Table 3. *S1: 16-row Philips Mx8000 IDT (Philips Healthcare, Andover, MA), S2: 64-row Siemens Somatom (Siemens, Erlangen, Germany).

For example: there are 16 studies for Nodule Layout #1 (4 exposures x 2 slice collimations x 2 pitch settings). Each study contains 30 series (10 repeat scans x 3 reconstructed slice thickness x 1 reconstruction kernel).

A key component of the CT lung phantom project is the ability to compare the estimated nodule size with the known *true* size or reference gold standard. As part of our project, volume was used as a surrogate measure of size. The true volume estimate of each synthetic nodule was derived from weight and density measures. Both the CIRS-and Kyotokagaku nodules were accompanied by density measures. Nodule weights were measured in our lab using a precision scale of 0.1 mg tolerance (Adventurer Pro AV 2646, Ohaus Corp, Pine Brook, NJ). Three repeat weight measurements were made and these weights were averaged to produce a final estimated weight for each nodule. Our estimates of the true volume of the synthetic nodules in each layout are summarized in **Table 3** along with approximated *xyz* location (based on 0.8mm slice thickness) of nodule center in the CT scans.

This phantom and the associated synthetic nodules designed in our lab have been used in a number of studies examining the accuracy and precision of volumetric measurements using CT

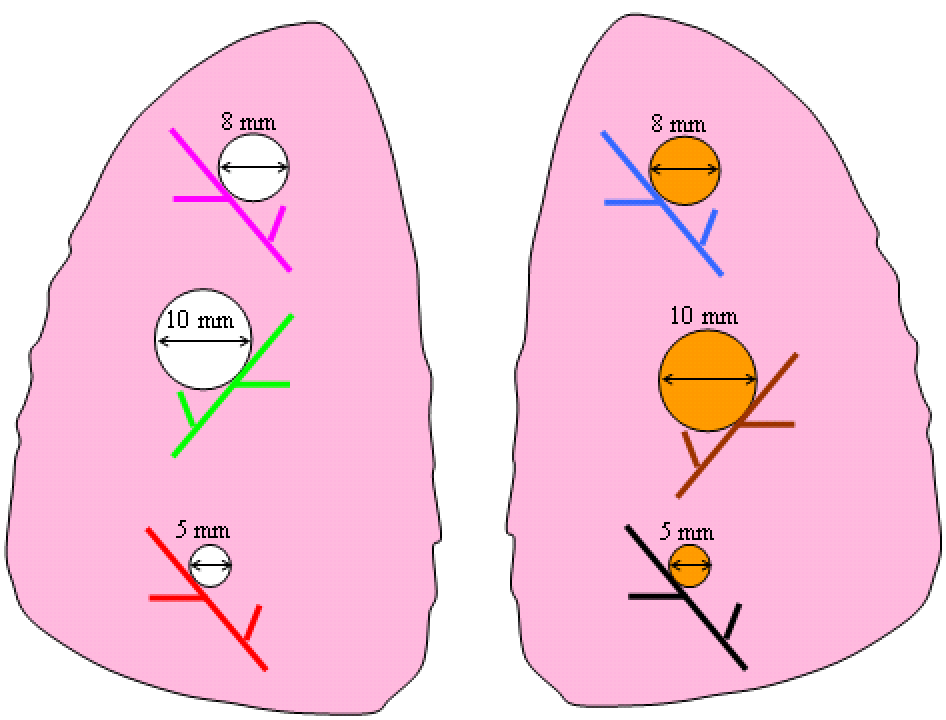
Nodule Layout	Right lung nodules					Left lung nodules				
	Nom. Diam. (mm)	Shape	HU	x y z	Vol (µl)	Nom. Diam. (mm)	Shape	HU	x y z	Vol (µl)
1	5	SPH	-630	177 342 192	71	5	SPH	-800	340 325 168	62
	8	SPH	-630	179 288 531	282	8	SPH	-800	343 274 540	245
	10	SPH	-630	170 309 385	522	10	SPH	-800	394 260 363	496
2	8	irr	-300	184 290 525	253	5	SPH	100	335 331 157	64
	12	irr	30	170 319 379	676	8	SPH	100	351 282 538	255
	15	irr	30	189 347 161	263	10	SPH	100	395 276 349	506
3	5	SPH	-630	192 350 562	71	5	SPH	100	338 328 580	64
	8	SPH	-630	185 287 208	282	8	SPH	100	355 278 212	255
	10	SPH	-630	170 324 354	522	10	SPH	100	394 270 390	506
	20	SPH	-630	157 251 190	4193	20	SPH	100	384 240 229	4215
	40	SPH	-630	168 280 198	34524	40	SPH	100	373 262 156	33781
4	10	ELL	-630	176 354 178	547	10	ELL	100	341 333 162	545

	20	ELL	-630	169 322 95	4210	20	ELL	100	401 296 122	4155
	10	LOB	-630	159 329 347	530	10	LOB	100	395 272 329	535
	20	LOB	-630	136 292 337	4305	20	LOB	100	349 350 268	4441
	10	SPI	-630	167 315 520	539	10	SPI	100	357 296 530	535
	20	SPI	-630	133 269 475	4335	20	SPI	100	386 248 503	4305

Table 3. Approximate center location and estimated true volume of synthetic lung nodules in each nodule layout based on 0.75mm slice thickness, 0.4mm slice increment CT scans. (SPH=spherical, ELL=elliptical, LOB= lobulated, SPI= spiculated, irr=irregular)

Please contact help@cancerimagingarchive.net who can direct you to Dr. Gavrielides with further scientific questions.

Appendix 1



-630HU

-800HU

Figure 3. Schematic diagram of Nodule Layout#1 in terms of nodule placement. Vessel branches within the anthropomorphic phantom were color coded for the purpose of mapping nodules to specific positions within the phantom's vasculature structure in a reproducible manner.

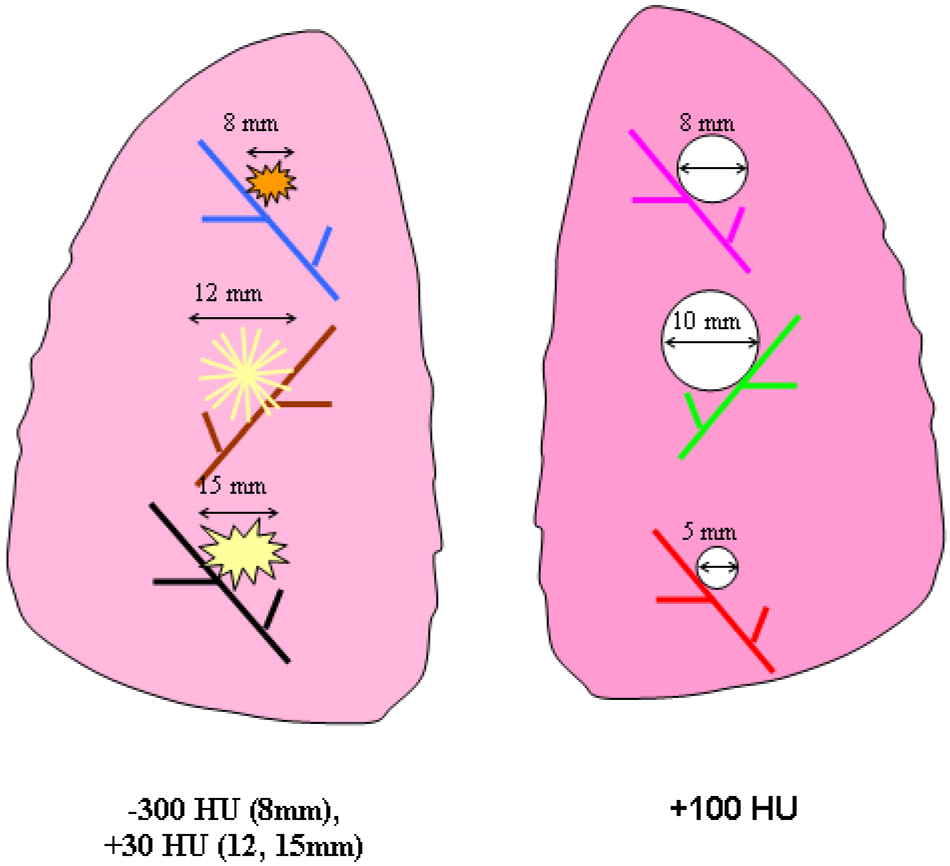


Figure 4. Schematic diagram of Nodule Layout#2 in terms of nodule placement.

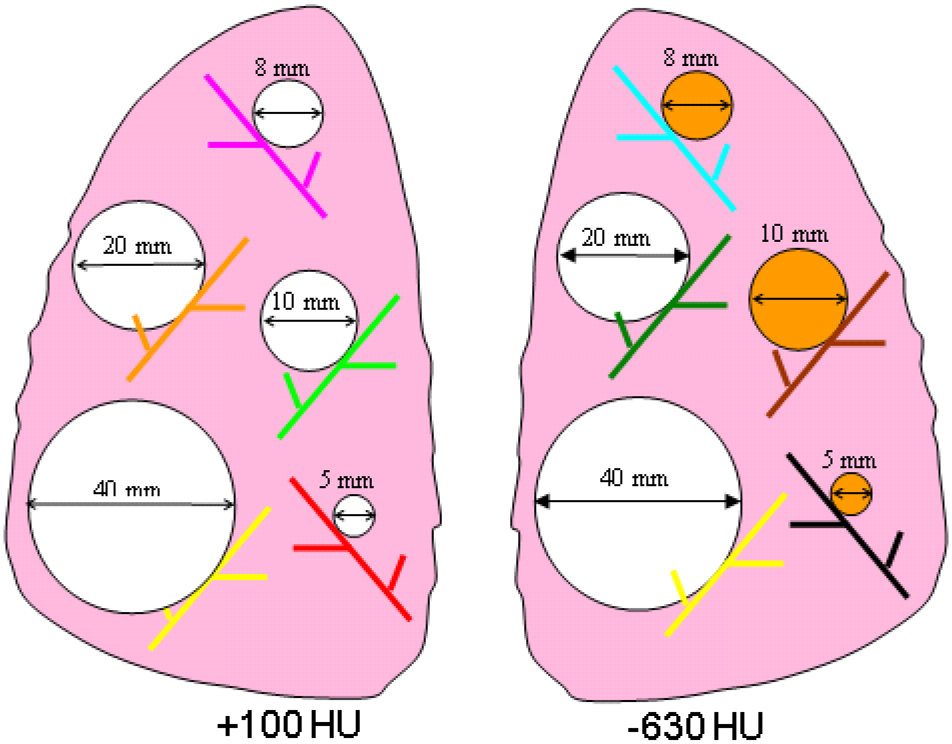


Figure 5. Schematic diagram of Nodule Layout#3 in terms of nodule placement.

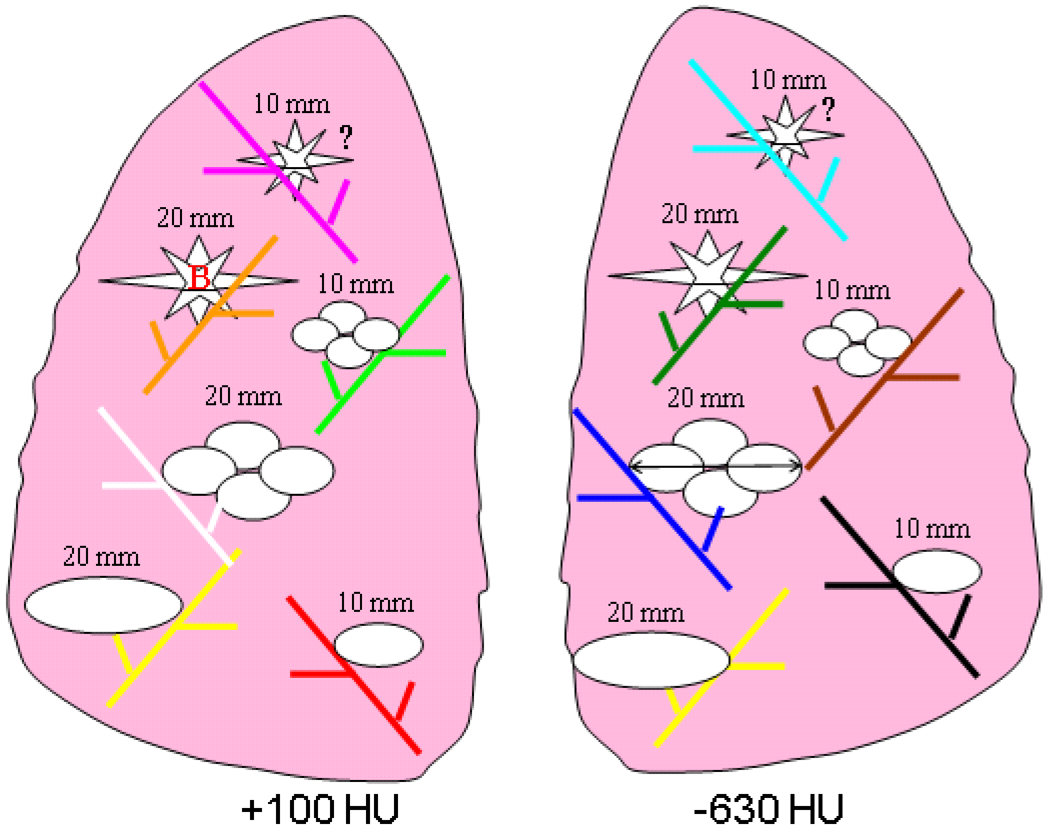


Figure 6. Schematic diagram of Nodule Layout#4 in terms of nodule placement.

Citations & Data Usage Policy

Citations & Data Usage Policy

Users must abide by the TCIA Data Usage Policy and Restrictions. Attribution should include references to the following citations:

Data Citation

Gavrielides, M. A., Kinnard, L. M., Myers, K. J., Peregoy, J., Pritchard, W. F., Zeng, R., Esparza, J., Karanian, J., & Petrick, N. (2015). **Data From Phantom FDA [Data set].** The Cancer Imaging Archive. https://doi.org/10.7937/k9/TCIA.2015.orbjkmux

Publication Citation

Gavrielides, M. A., Kinnard, L. M., Myers, K. J., Peregoy, J., Pritchard, W. F., Zeng, R., Esparza, J., Karanian, J., & Petrick, N. (2010). **A resource for the assessment of lung nodule size estimation methods: database of thoracic CT scans of an anthropomorphic phantom**. In Optics Express (Vol. 18, Issue 14, p. 15244). https://doi.org/10.1364/oe.18.015244, PMCID: PMC3408907

TCIA Citation

Clark, K., Vendt, B., Smith, K., Freymann, J., Kirby, J., Koppel, P., Moore, S., Phillips, S., Maffitt, D., Pringle, M., Tarbox, L., & Prior, F. (2013). **The Cancer Imaging Archive (TCIA): Maintaining and Operating a Public Information Repository**. In Journal of Digital Imaging (Vol. 26, Issue 6, pp. 1045–1057). https://doi.org/10.1007/s10278-013-9622-7

Questions may be directed to help@cancerimagingarchive.net.

Other Publications Using This Data

TCIA maintains a list of publications which leverage our data. If you have a manuscript you'd like to add please contact TCIA's Helpdesk.

1. Kalpathy-Cramer, J., et al, (2016) "Radiomics of Lung Nodules: A Multi-Institutional Study of Robustness and Agreement of Quantitative Imaging Features." Tomography 2(4)430-437. doi: 10.18383/j.tom.2016.00235
2. Peskin AP, Dima AA, Saiprasad G. **An Automated Method for Locating Phantom modules in Anthropomorphic Thoracic Phantom CT Studies.** The 2012 International Conference on Image Processing, Computer Vision, and Pattern Recognition. 2012. (IPC conference link)

Versions

Version 2 (Current): Updated 2017/08/30

Data Type	Download all or Query/Filter
Images (DICOM, 728.5 GB)	*Download* *Search* (Download requires the NBIA Data Retriever)
DICOM Metadata Digest (CSV)	*Download*
Updated Description (.DOC)	*Download*

Version 1: Updated 2014/08/04

Data Type	Download all or Query/Filter
Images (DICOM, 125.4GB)	*Download*
DICOM Metadata Digest (CSV)	*Download*