ARIC

Manual 13
MRI Procedures
ARIC-NCS III

MAYO CLINIC

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1. List of Abbreviations

3T	3 Tesla
ADIR	Mayo Aging and Dementia Imaging Research Lab
ARIC	Atherosclerosis Risk in Communities
CC	Coordinating Center
DICOM	Digital Imaging and Communications in Medicine
DTI	Diffusion Tensor Imaging
FOV	Field of View
FLAIR	Fluid-Attenuated Inversion Recovery
IRB	Institutional Review Board
MB	Multi-Band
MPRAGE	Magnetization Prepared - Rapid Gradient Echo
MRI	Magnetic Resonance Imaging
NCS	Neurocognitive Study
PASL	Pseudo-Continuous Arterial Spin Labeling
QC	Quality Control
VPN	Virtual Private Network
XNAT	Extensible Neuroimaging Archive Toolkit

2. Overview

This manual of operations describes magnetic resonance imaging (MRI) procedures pertinent to MRI technologists working on the Atherosclerosis Risk in Communities Neurocognitive Study (ARIC-NCS). Details about the procedures performed by field staff are described in ARIC Manual 34 (MRI and PET Procedures).

3. Study Design

MRI scans of the brain will be acquired during 2020-2025. MRI scans from ARIC Visit 6 (2016-2021), ARIC Visit 3 (1993-5), ARIC Brain MRI Study (2004-6) and ARIC NCS (2010-12) are referred to as Scan I, Scan II and Scan III, respectively). If for any time point scan quality is not acceptable, the sequence(s) must be repeated while the subject is still present.

4. Site Qualification

Prior to site qualification, your MRI site will receive an electronic copy of the study MRI protocol (1) for human scans and (2) for phantom scans provided by the Mayo Aging and Dementia Imaging Research (ADIR) Lab. You will receive email notification and directions for installing these MRI protocols. This should be loaded onto the one and only 3 Tesla (3T) system that will be used for the study, labeled on the scanner directory, and not modified for the duration of the study. The one exception is in the case of a hardware/software upgrade of the system used for the study which is discussed below.

Prior to scanning any subject for the study at a particular site, that site must complete site qualification. Every MRI Technologist involved with this study, must perform a site qualification scan. The Coordinating Center (CC) has created unique MRI Technologist Codes/ID's for each MRI Tech that has been named involved with scanning for this study. These codes/ID's will be entered on the reporting form for each subject.

The ADIR Lab Quality Control (QC) team will perform a quality control check (including protocol compliance) on each individual's site qualification scan data. After review of each individual scan from an individual technologist and the scan has passed, an e-mail will be sent to the MRI Tech, PI, SC and the Coordinating Center for ARIC-NCS III informing them they are now certified to scan ARIC-NCS III subjects.

The CC will track the MRI Technologist(s) performance throughout this study on the following: protocol violations (changing parameters), incomplete data, too much motion and did not repeat the sequence, etc. With this tracked performance, it is extremely crucial that the MRI Technologist(s) follow the protocol precisely and educate their subjects on holding still. If the CC does not feel the MRI Technologist(s) has had a great performance of their subjects throughout this study, they will require the MRI Tech to become re-trained/re-certified.

> **Please Note**:
> - The same 3T MRI scanner must be used for site qualification and **ALL** subsequent subject scans during the trial. If the same MRI scanner is not used, the subject will need to be re-scanned on the qualified scanner.
> - You will be supplied electronic protocols by the ADIR Lab. This can be installed by your physicist or engineer. This will ensure that you have the correct protocol for your MRI scanner. If you have any questions about this procedure please contact: aricmri@mayo.edu.
> - **Use only the electronically imported ARIC-NCS III MRI acquisition protocols.**

5. Subject Pre-screening
All subjects must be screened by the Study Coordinator for standard MRI contraindications. However, subjects must also be screened for MRI contraindications immediately before the MRI scan using your local standard protocol. Contraindications include, but are not limited to:
- The presence of non-removable ferrous metal objects
- Aneurysm clips
- Pacemakers
- Other contraindications such as defibrillators, etc.

Consent: All sites will consent participants with the informed consent form approved by their institutional ethics committee.

Sedation: Site/subject dependent.

6. MRI Scanning

6a. Subject Safety and Monitoring
All sites must follow the standard subject consent protocols as approved by their local Institutional Review Board (IRB).

6b. Subject Confidentiality
Each site will be responsible for anonymizing all patient specific information according to each site's own local laws and regulations. Please follow the specific instructions for subject anonymization prior to sending the images (*Section 11*).

6c. Subject Positioning
Proper subject positioning is crucial for a successful MRI exam. Therefore, it is important that each subject is positioned in the same manner for each and every MRI exam.

Please follow the procedures below for positioning the subject in the head coil:
- Place clean sheet on scanner table and coil cradle.
- In addition to standard room exclusions, ensure the subject has removed their dentures as well as any hair clips, combs, earrings, necklaces, etc.
- Remove all upper body clothing with metallic trim, such as zippers, buttons or embroideries that may cause artifacts in the MRI images.
- Position the subject so their head and neck are relaxed, but without rotation in either plane. Proper placement in the head coil is crucial because scans are acquired straight, not in an oblique orientation. The subject should also be well supported in the head coil to minimize movement. Motion artifacts may result in data rejection and request for a re-scan.
- Support under the back and/or legs can help to decrease strain on the knees and back as well as assisting in the stabilization of motion in the lower body.
- **Once subject has been positioned, snugly place sponges along the sides of head and a Velcro strap across forehead (if available). This will decrease the possibility of patient motion and furthermore it will reduce the chances of a re-scan**.
- Align the centering crosshairs on the subject's nasion (directly between the eyebrows) at every scanning session.
- Center the head coil over the subject's head, making sure the subject is high enough in the coil to prevent signal loss at the inferior aspect of the brain.
- Remind subject to hold as still as possible and advance subject to the iso-center of the scanning bore.

Please Note:
- It is extremely important that the subject is positioned in the same manner, at the nasion, for the MRI exam.

7. MRI Acquisition Sequences
- If the subject is not positioned properly, please adjust the subject in the head coil and re-scout. Continue repositioning and scouting until the subject is correctly centered in the head coil.

GOOD   NOT ACCEPTABLE
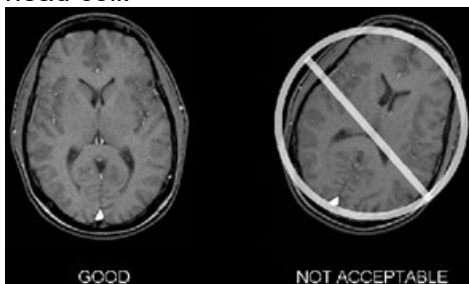
- Once the subject is positioned correctly, the following sequences are to be run.

ARIC-NCSIII
- 3 Plane Localizer
- Accelerated Sagittal Magnetization Prepared - Rapid Gradient Echo (MPRAGE) Volumetric
- Sagittal 3D Fluid-Attenuated Inversion Recovery (FLAIR)
- Axial 3TE T2 STAR (Straight Axial – Not Oblique)
- Axial Multi-Band (MB) Diffusion Tensor Imaging (DTI) P-A (Straight Axial – Not Oblique) (Sites F, J, and M)

- Axial Multi-Band (MB) Diffusion Tensor Imaging (DTI) A-P (Straight Axial – Not Oblique) (Sites F, J, and M)
- Axial DTI (Straight Axial – Not Oblique) (Site W – non-MB)
- Sagittal 3D T2 SPACE (No oblique)
- Axial 3D Pseudo-Continuous Arterial Spin Labeling (PASL) (Site, J only)

**NOTE: Entire brain must be covered for all series.**

Prescription of Accelerated Sagittal MPRAGE
- **Do Not Angle or change any parameters**
- Box A – Axial image. Field of View (FOV) placed in center to avoid side-to-side wrap.
- Box B – Sagittal image. FOV placed anterior to avoid nose wrap.
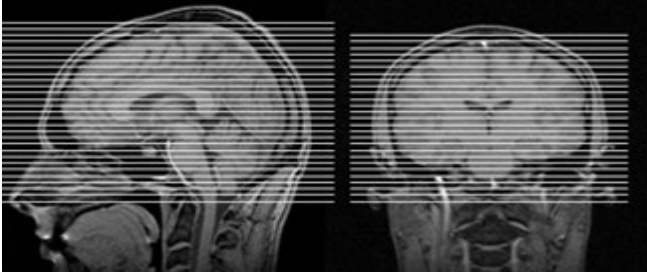- Box C – Coronal image. FOV placed to assure top of the brain is covered.

Prescription of Sagittal 3D FLAIR
- **Do Not Angle or change any parameters**
- Box A – Axial image. FOV placed in center to avoid side-to-side wrap.
- Box B – Sagittal image. FOV placed anterior to avoid nose wrap.
- Box C – Coronal image. FOV placed to assure top of the brain is covered.
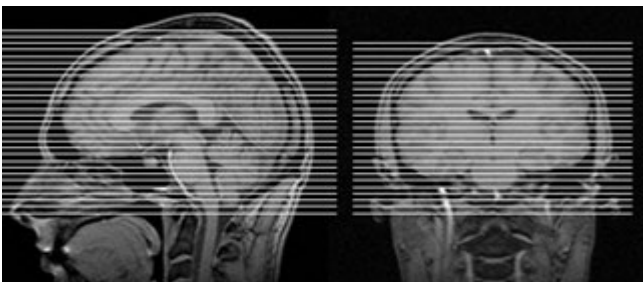
Prescription of Axial 3TE T2 STAR
- **Straight Axial, do not oblique/angle the slices**
- Ensure total brain coverage position from inferior to superior

Prescription of Axial DTI
- **Straight Axial, do not oblique/angle the slices**
- Position from inferior to superior

Prescription of 3D T2 SPACE
- **Do Not Angle or change any parameters**
- Box A – Axial image. FOV placed in center to avoid side-to-side wrap.
- Box B – Sagittal image. FOV placed anterior to avoid nose wrap.
- Box C – Coronal image. FOV placed to assure top of the brain is covered.


Prescription of 3D PASL (Site J only)
- The inferior edge of the ASL volume must be positioned at the bottom of the cerebellum
- Place box close enough to the back of the skull to minimize the chance for nose wrap
  - Minimal nose wrap is ok, if there is significant nose wrap and it is obstructing the brain tissue/anatomy, re-position and run the series again

8. Anticipation of Scanner Software and/or Hardware Upgrades
The ADIR Lab requires at least 2 weeks or more notification prior to any software and/or hardware upgrades for any scanner involved in the imaging study. The site will be required to scan a phantom prior to resuming scanning study subjects.

Example:
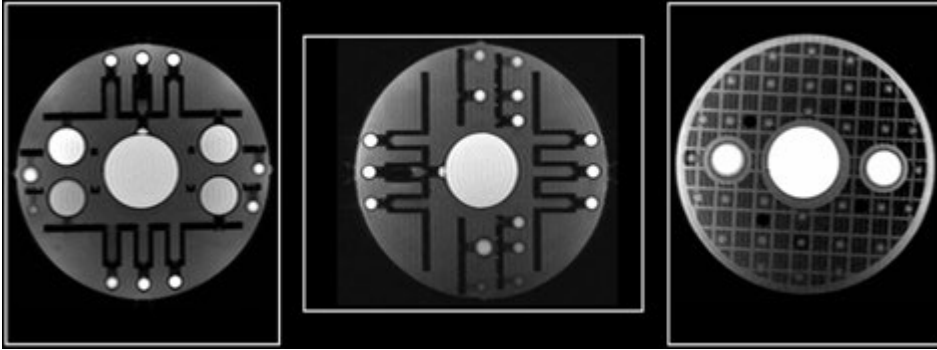
- Scan the entire protocol with any head phantom to ensure the protocol runs following the upgrade

9. Scan Discontinuation

If the subject experiences discomfort in the MRI, every effort should be made to adjust the table, head coil, etc. to allow scan continuation. If the subject elects not to complete the scan, then the MRI must be abandoned, and the Study Coordinator must be notified.

10. Anonymizing Data

Each site will be responsible for anonymizing all patient-specific information according to local laws and regulations. At a minimum, the following Digital Imaging and Communications in Medicine (DICOM) fields will be replaced:

- **Patient ID:** Must be replaced with the Participant ID provided by ARIC CC
- **Nomenclature: Sxxxxxx**
    - **S= Field Center identifier (F, J, M, or W)**
    - **xxxxxx= Study Participant ID (6 numeric digits)**
        - **Example = F123456**

Study Coordinator should provide the Subject ID to the MRI Technologist prior to the exam.

11. Data Transfer

Data transfer must be electronic in standard DICOM format in order to meet turn around requirements, preferably within one business day of the exam.

Data transfer will occur via Virtual Private Network (VPN) authorizations assigned to each site. Each site's IT group has worked with the ADIR Lab to establish their site's connection to our VPN.

The software used to send DICOM can be any tool with the ability to send images. Please use the following information for sending it to the correct DICOM receiver.

Site	Protocol/Project	HOST	IP ADDRESS	AET TITLE	SCP PORT
Minnesota/CMRR	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_M	8002
Minnesota/CMRR	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_M_Q	8004

Jackson, Mississippi	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_J	8006
Jackson, Mississippi	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_J_Q	8008
Washington County/Hagerstown	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_W	8010
Washington County/Hagerstown	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_W_Q	8012
Forsyth/Wake Forest	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_F	8014
Forsyth/Wake Forest	ARIC-NCSIII	aric.mayo.edu	129.176.134.204	ARIC_NCS3_F_Q	8016

If you are unable to send anonymized DICOM from your image storage solution, the ADIR Lab suggests DicomBrowser as one possible solution. A user guide to its features are included in *Section 15*.
Additional data transfers or copies may be requested in the event that a data transfer is interrupted or incomplete.

12. On-site Clinical Reads
Every subject must receive a clinical read by an on-site radiologist at each MRI facility. The clinical read should follow standard local practice and a clinical dictation of the read should be transferred to the Study Coordinator at the referral site. Scan interpretations for diagnostic clinical purposes will **not** be provided by the ADIR Lab.

13. Archive Procedures
Every MRI for the study must be archived at the MRI facility following the department's standard local practice in addition to the data transfer to the ADIR Lab immediately after the MRI scan. Additional data transfers or copies may be requested by the ADIR Lab/CC in the event that a data transfer is interrupted or incomplete.

14. Request for Repeat MRI Scans
Due to limited budgets, there are no funds for rescanning. Please exercise your best scanning techniques when scanning the subject with close attention to the following:
- Subject positioning at the nasion (*Section 6c*)
- Remind subject to remain as still as possible
- Use the correct MRI protocol
  - ARIC-NCSIII
- Do NOT change MRI parameters
- Review the images following each series acquisition

15. DicomBrowser User Guide
DicomBrowser is an application for inspecting and modifying DICOM metadata in many files at once. A single imaging session can produce thousands of DICOM files. DicomBrowser allows users to view and edit a whole session—or even multiple sessions—at once. Users can save the original or modified files to disk or send them across a network to a DICOM C-STORE service class provider, such as a PACS or an XNAT.

DicomBrowser is available at the following link: https://wiki.xnat.org/xnat-tools/dicombrowser.
This link includes a Video Tutorial on anonymizing DICOM using the application.

Users may also use the steps below or on this site to anonymize and send DICOM:
https://wiki.xnat.org/xnat-tools/dicombrowser/how-to-use-dicombrowser:

15a. Load DICOM into DicomBrowser
1. With DicomBrowser installed and started, select *File\Open* from the Menu Bar:
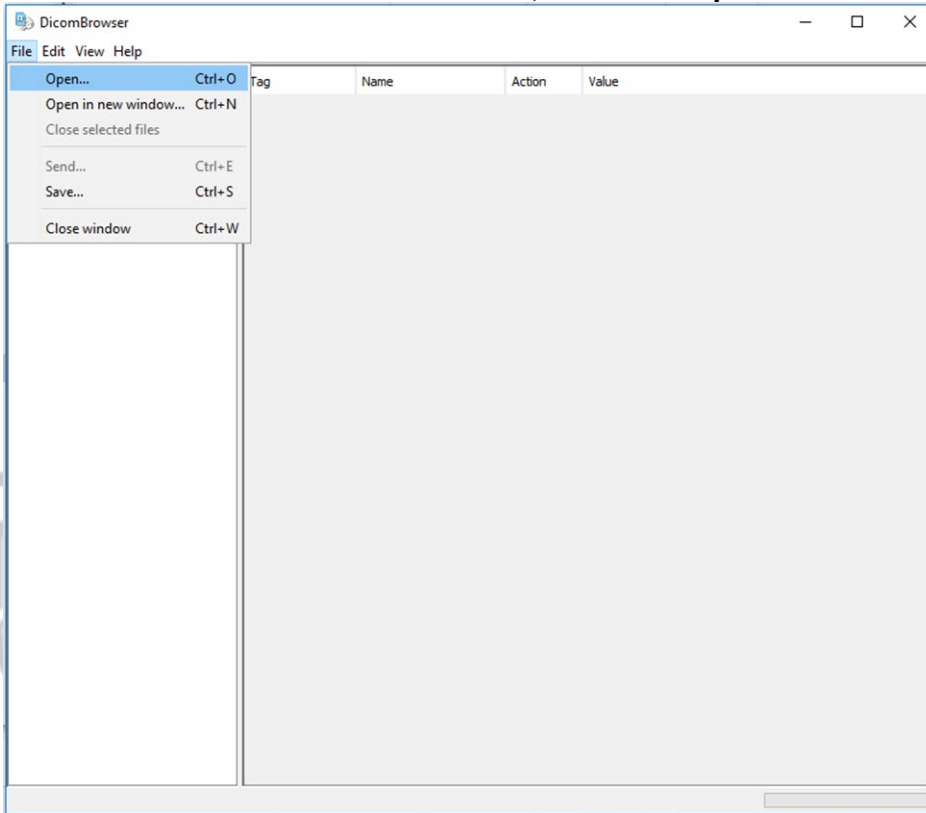
2. Using the **Select DICOM files** dialog box, navigate to the desired DICOM directory to be anonymized and\ or sent and click the **Open** button:

   NOTE: Select either individual DICOM files or directories. If a directory is selected, all DICOM files in that directory and its contained directories are loaded.

   The browser can load thousands of files at a time but trying to view attributes for more than a few thousand files can exceed the Java memory limit.

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The memory limit can be increased, but the application may experience delays. Therefore, it is better to load only as many sessions as the machine can gracefully manage.
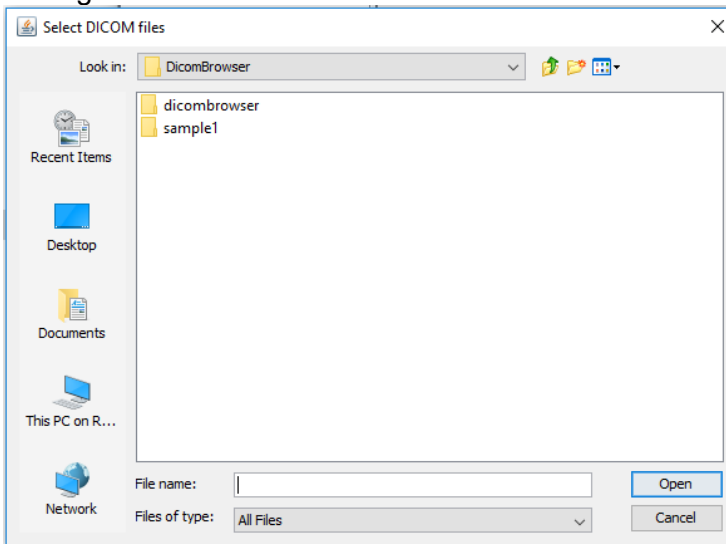
3. When the files have loaded, a list of Patient IDs appears on the left side of the browser window. DicomBrowser arranges data files in a hierarchy in which Patient is the top level; below Patient is Series, Study, and, at the bottom, Image (or Instance), representing a single DICOM data object. This hierarchy might or might not mirror the organization of these files in directories on disk.

Each Patient ID label has an expander button to its left; clicking this expander shows all the Studies loaded for that patient. Clicking the expander next to a Study label shows all the contained Series and clicking the expander next to a Series label shows all the contained Images.

Clicking on a label itself (Patient, Series, Study, or Image) selects that label, which causes the browser to load all the associated attributes. These attributes are displayed in a table on the right side of the browser window. Selecting a single Image causes just one file to be loaded; selecting a Patient may cause hundreds of files to be loaded, which could take a few minutes.

When a selection has been made on the left side, the attributes for all files associated with the selection are shown in a table on the right side. The table shows, for each attribute, its DICOM tag, the name of the attribute, a summary of whether and how the attribute has been modified, and the value(s) of that attribute, after any changes have been applied.

The Action column shows whether each attribute has been changed. When files are first loaded, the label in this column is **Keep**, meaning that the browser will keep the original values. Other possible values are **Clear**, if the attribute contents have been erased; **Delete**, if the attribute has been removed entirely; **Assign**, if the attribute has been set to a new value; or **Mixed**, if the current file selection includes multiple files for which different operations have been specified.

4. Files that have been loaded can be closed and removed from the browser view by selecting them and then choosing *File\ Close selected files* from the Main Menu:
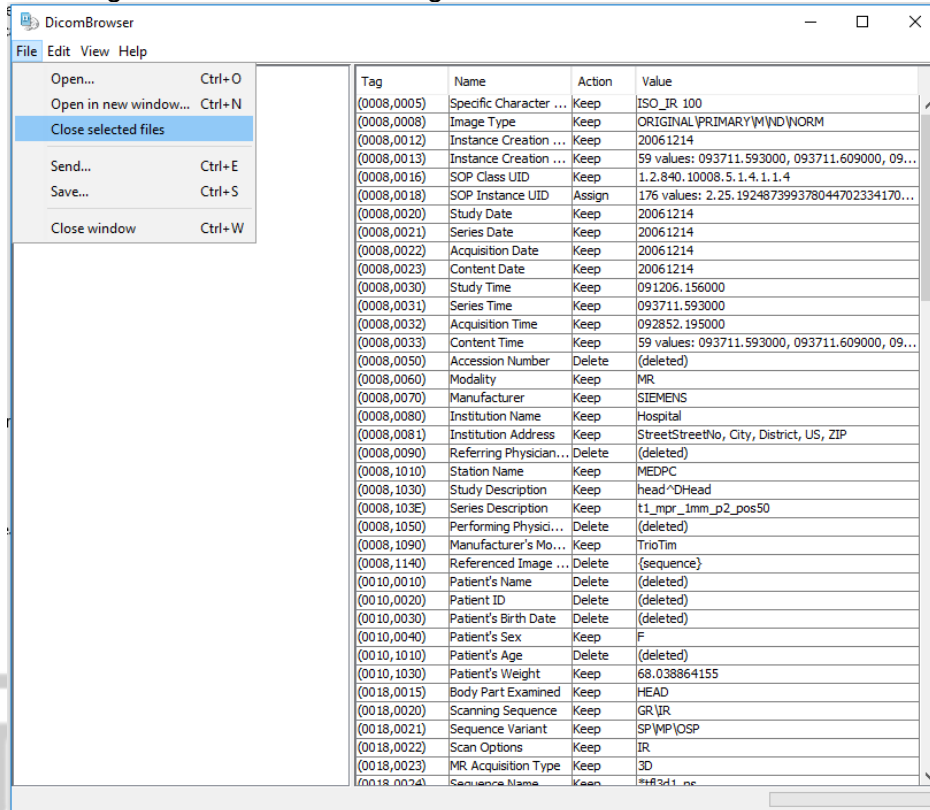
15b. Send Files with DicomBrowser

1. In the *Send files to DICOM receiver* dialog box, enter the **remote host**, **port**, and **remote AE title** using the following screenshot and table as guides:
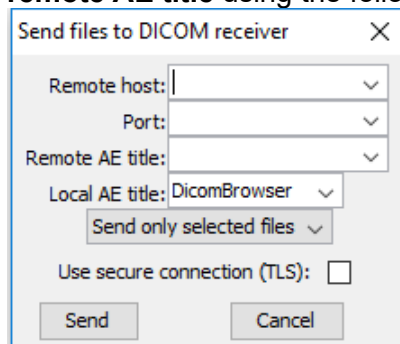

2. From the drop-down menu, select one of the following options and click the **Send** button:
   - **Send only selected files**
   - **Send all files**

## 15c. Modify DICOM in DicomBrowser

1. If the DICOM has not yet been de-identified (anonymized), from the Main Menu, select *Edit\Apply script…* and navigate to and select the desired anonymization script and select the Open button:

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NOTE: Please refer to the link to the DicomBrowser application, above, for sample anonymization scripts:
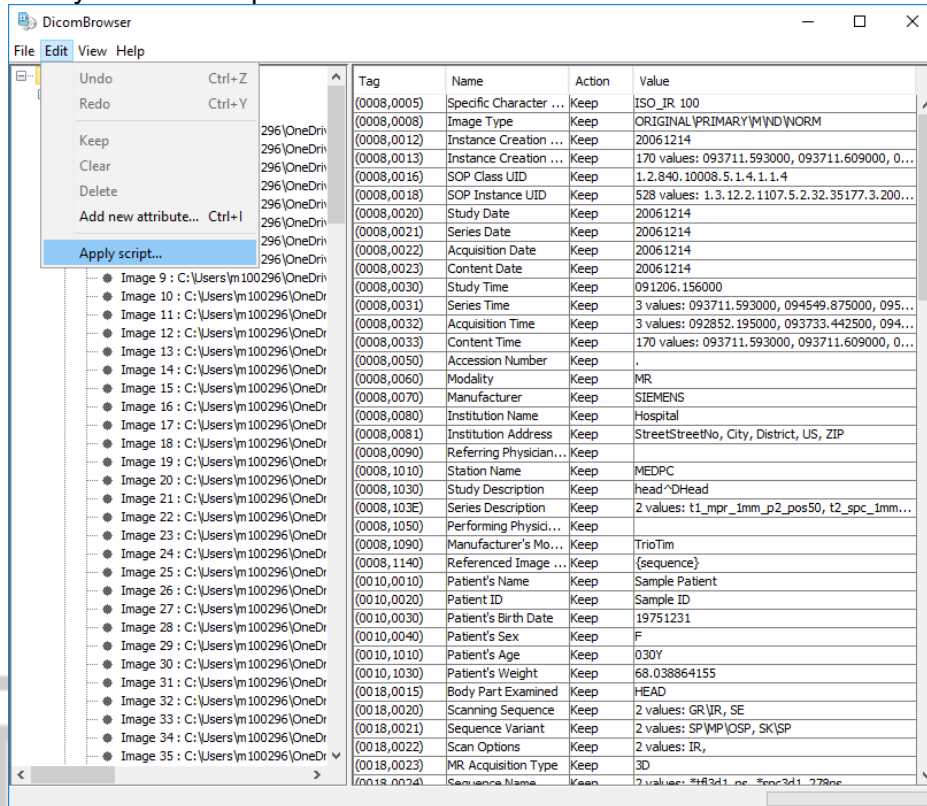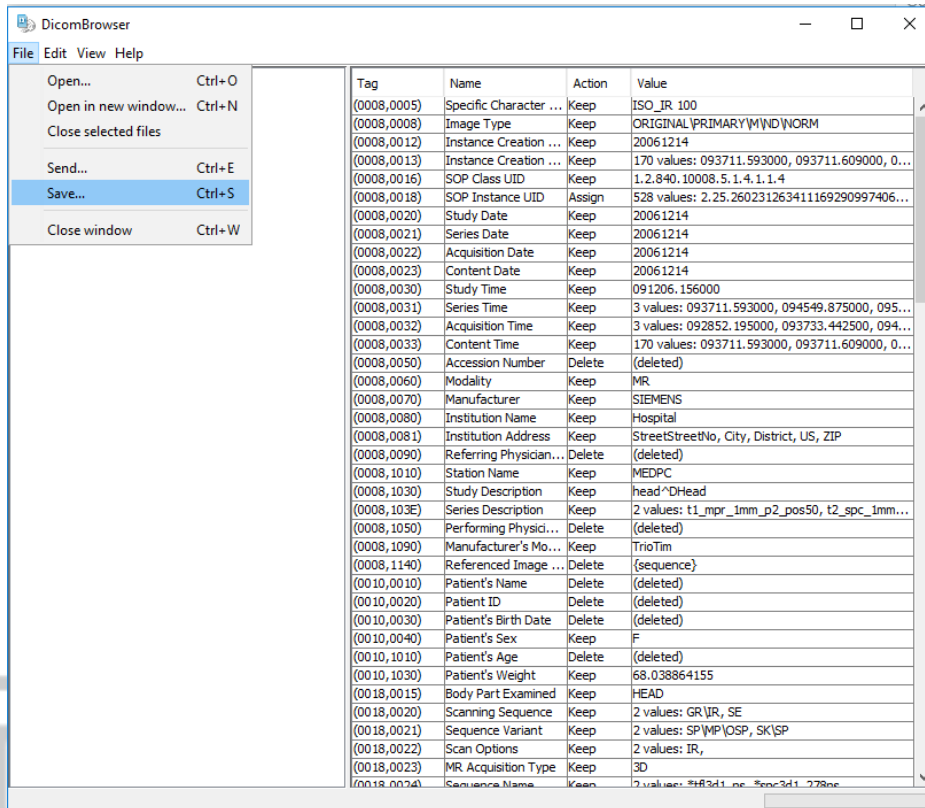

2. At the ***Opening metadata modification script***… dialog box, chose to apply the script to all files by selecting the ***All Files*** button:
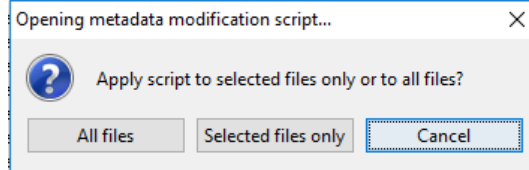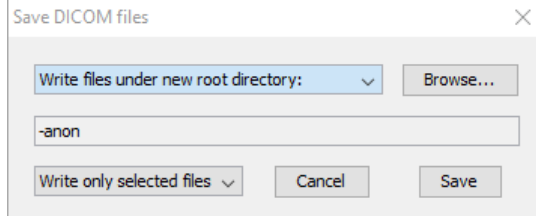

3. Scroll through the DICOM values and verify no identifying information remains.

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4. Save the anonymized files to a different directory by selecting *File\Save…* from the Main Menu:

5. In the *Save DICOM files* dialog box, select the *Write files under new root directory:* option from the drop-down menu:

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6. From the **Select output directory** dialog box, navigate to the desired save-to directory and click the **Save** button:
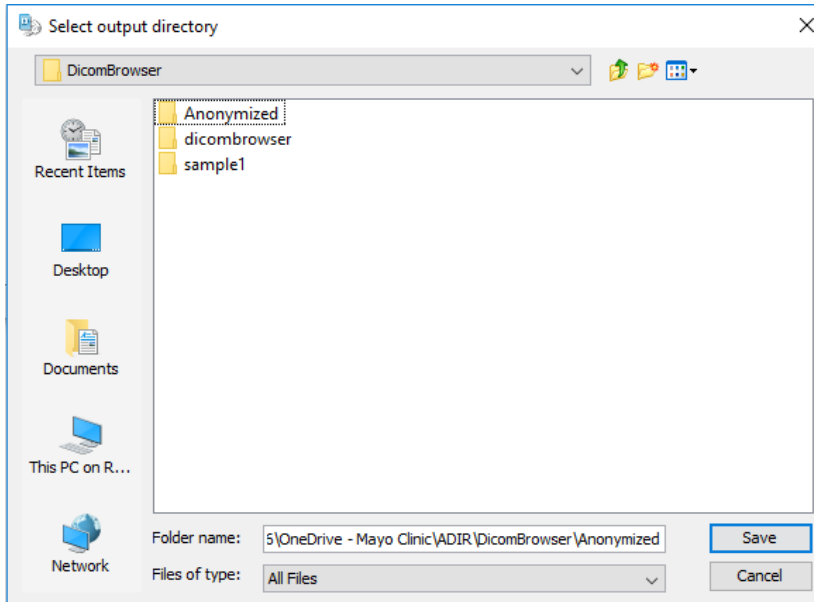

7. Back in the **Save DICOM files** dialog box, select the **Write all loaded files under** option from the Dropdown menu and click the **Save** button:

NOTE: The dialog box that appears offers several options for naming the saved files:
  o Write files in adjacent directory with suffix
    For each directory in the original file structure, a new directory is created with the original pathname with the given suffix appended. The new directory is filled with modified versions of the DICOM files in the original directory.
  o Write files in same directory with suffix
    New files are written in the same directory structure as the originals, but each new filename has the given suffix.
  o Write files under new root directory
    A new root directory (specified by the user) is created, and all modified files are written under that root in a directory structure that mirrors the original.
  o Overwrite existing files

The original DICOM files are replaced by the modified files.
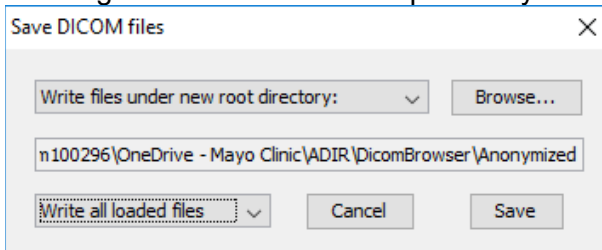
8. To send anonymized DICOM objects to a remote DICOM C-STORE receiver, select **File\Send** from the Main Menu:

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