Draft Abdominal Ultrasound Manual of Operations for the ARIC Study

1. Introduction

ARIC visits will include an ancillary ultrasound study to assess abdominal aortic diameter in participants who come to the clinic. This ancillary is called the "Identifying Epidemiological Risk Factors for Abdominal Aortic Aneurysm (AAA)" Study. AAA is a common disease in the elderly and an important public health problem. Ruptured AAA is associated with a high mortality rate and an important cause of death in the elderly. The causes of AAA are not well understood and there are no specific pharmacological agents that have been shown to be effective in preventing or reducing AAA progression. The ARIC ultrasound examination of the abdominal aorta will identify undiagnosed AAA cases to allow epidemiological studies of AAA in this large prospective cohort. Data from this study will provide new insights into the possible causes of AAA, and potentially improve prevention and management of early AAA to prevent ruptures. This manual provides background information and instructions on operation procedures for the abdominal ultrasound examination. High quality data collected by ARIC ultrasound techs are critical to the success of the study.

2. Overall Study Objectives and Processes

a. Objectives

Objectives

Aortic Ultrasound	• The objective of the ARIC Visit 5 aortic ultrasound study is to identify abdominal aortic aneurysms to allow the possible identification of new risk factors for AAA.
UMN Aortic Imaging Core Lab (AICL)	• To provide clinical interpretation and quality control of selected aortic ultrasounds.
Field Center Instruction Manual	• To instruct field centers on how to perform aortic ultrasounds and send study images and data.

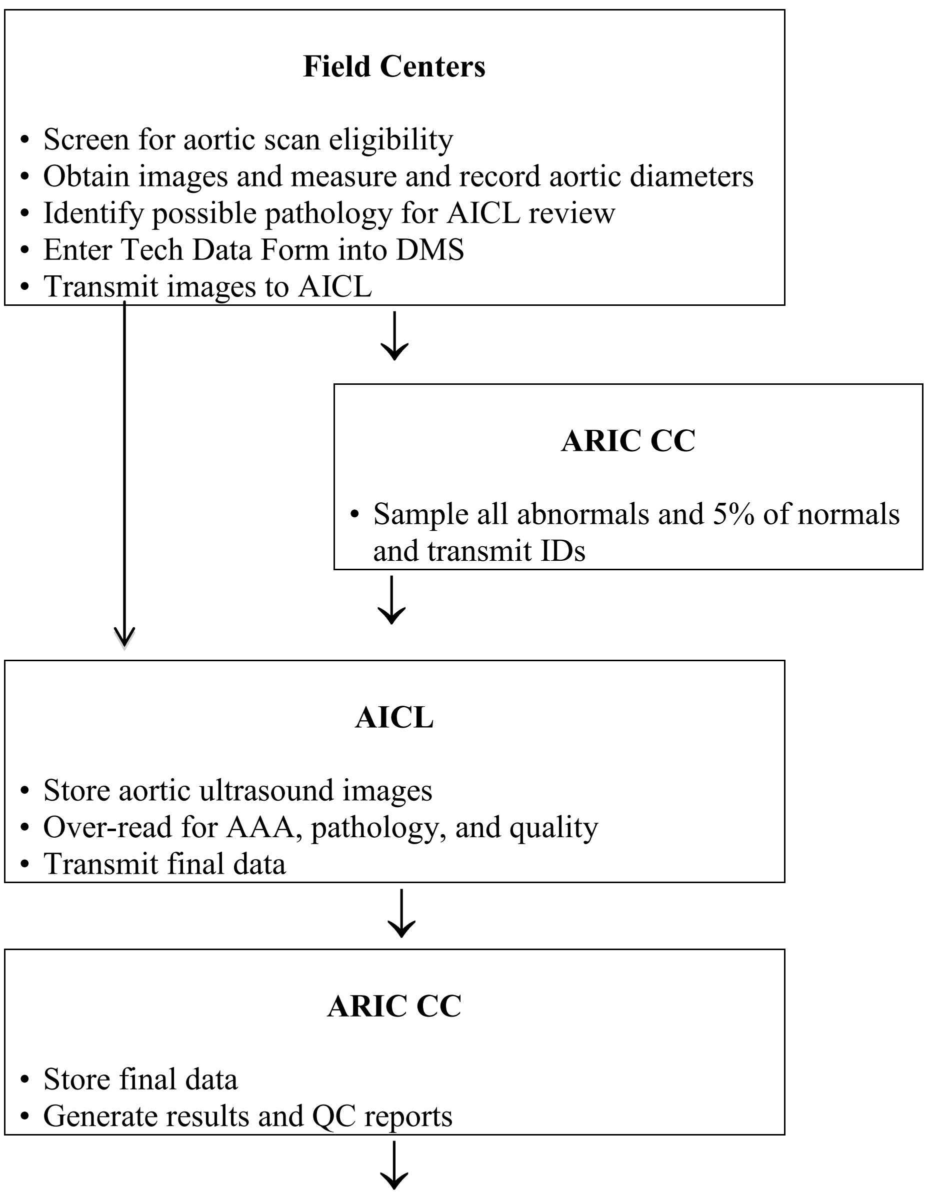
Roles and Responsibilities

Field Center Technologists	• Perform high-quality study aortic ultrasounds per the protocol contained in this document and record onto the AAA Technologist Data Collection Form aortic diameters and flag other possible abnormalities for AICL physician review. • Transmit Data Collection Forms to the ARIC Coordinating Center and images to the AICL.
ARIC Coordinating Center	• Receive Data Collection Form data from field centers, sample these, and send the sample IDs to the AICL. Then, to receive final clinical over-reads back from the AICL. • Serve as the primary liaison between the AICL and field centers for study deficiencies, chronic poor quality studies and other issues related to overall site performance. • Prepare results letters.

UMN Aortic Imaging Core Lab	• Receive and store all aortic ultrasound images. • Over-read selected aortic ultrasounds. • Train and certify each field center sonographer in the aortic protocol. • Provide field centers feedback on poor quality scans, and queries for technical/process improvement. • Serve as a resource for sites for all aortic ultrasound-related questions.

b. Study-Wide Process Overview

Field center technologists will enter the Technologist Data Collection Form into the ARIC Data Management System. They also will electronically transmit aortic ultrasound images to the AICL. The ARIC Coordinating Center will sample the Data Forms and send IDs to the AICL for over-reading and return of data to the ARIC CC.



Field Centers
• Retrieve and send result letters to participant and MD • Review QC and take action

3. AAA Protocol

a. Participant Exclusion Criteria
   A question on the Visit 5 Safety Screener questionnaire asks about:
   i. Previous AAA repair or previous aortic bypass surgery for occlusive atherosclerotic disease
      1. Open surgery
      2. Endovascular

If this question is answered "yes," exclude the participant.

b. Limitations that may require extra technologist effort
   i. Bowel gas
   ii. Obesity
   iii. Recent abdominal surgery

c. Preparation
   i. NPO for 6 hours before the examination is strongly preferred. Rare exceptions will be accepted to accommodate ARIC clinic schedules; for example, if the participant must eat before the aortic exam can be completed. If the participant forgets to fast before arrival, s/he should be scanned late in the visit to approximate fasting.

d. Exam
   i. Equipment and supplies
      1. High resolution real time duplex ultrasound equipment: Philips IE33
      2. C 5-1 Philips transducer
      3. Stretcher
      4. Acoustic coupling gel
      5. Washcloths, drapes
      6. Digital imaging archiving system
      7. AAA Technologist Data Collection Forms
      8. CDs for image backup per echo protocol.
   ii. Required views
      Techs will identify "potential AAAs" (maximal diameter ≥2.8 cm), for physician confirmation.
      1. Transverse image with AP and transverse diameters
         a. Proximal aorta just below the level of the superior mesenteric artery
         b. Proximal infrarenal aorta 2 cm below the renal arteries
         c. Distal infrarenal aorta 1 cm above the bifurcation
         d. Point of maximal infrarenal aortic diameter if different from b. or c.
         e. In the presence of a potential AAA (maximal diameter ≥ 2.8 cm) take additional images to demonstrate the maximum diameter in the

transverse view.

2. Longitudinal views
   a. Image the infrarenal abdominal aorta from the renal arteries to the bifurcation.
3. Also image thrombus or dissection if present

iii. Documentation

1. Images are to be stored and transmitted per ARIC protocol
2. The AAA Technologist Data Collection Form will also be filled out recording the diameters to one decimal. These will be entered per ARIC protocol.

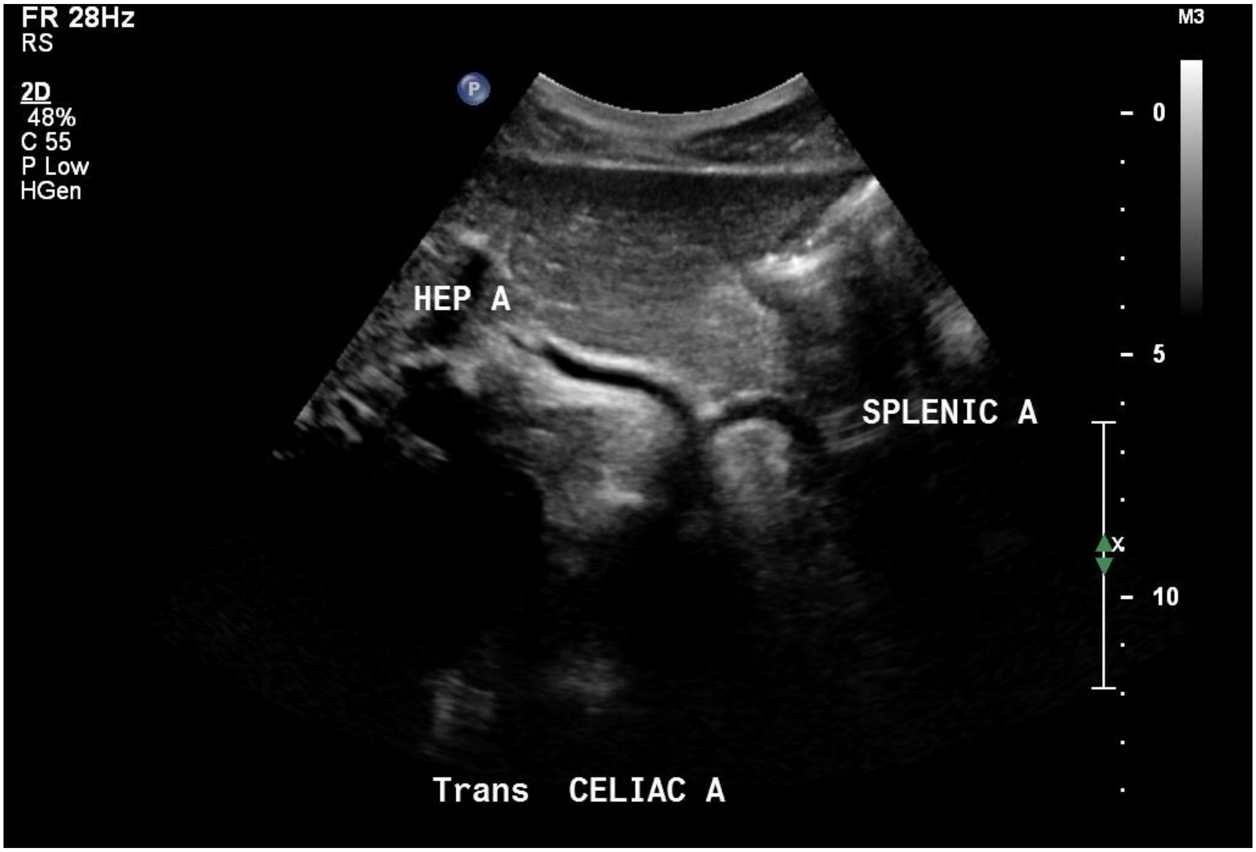
e. General considerations

i. Anatomy

1. The thoracic aorta passes through the diaphragm at the level of the 12th thoracic vertebral body to become the abdominal aorta. It lies slightly to the left of midline and bifurcates at approximately the level of the 4th lumbar vertebral body. Relative to the surface anatomy it starts at the xyphoid and ends at the umbilicus, with a length of 13 cm or 6 inches.
2. The first major vessel to originate from the abdominal aorta is the celiac artery, which arises anteriorly and immediately below the diaphragm. The celiac artery is usually short, less than 1 cm. **(See Figure 1.)** On the transverse plane it divides into a wide "Y", the so-called "seagull sign". The right limb is the common hepatic artery and the left the splenic artery. **(See Figure 2.)**

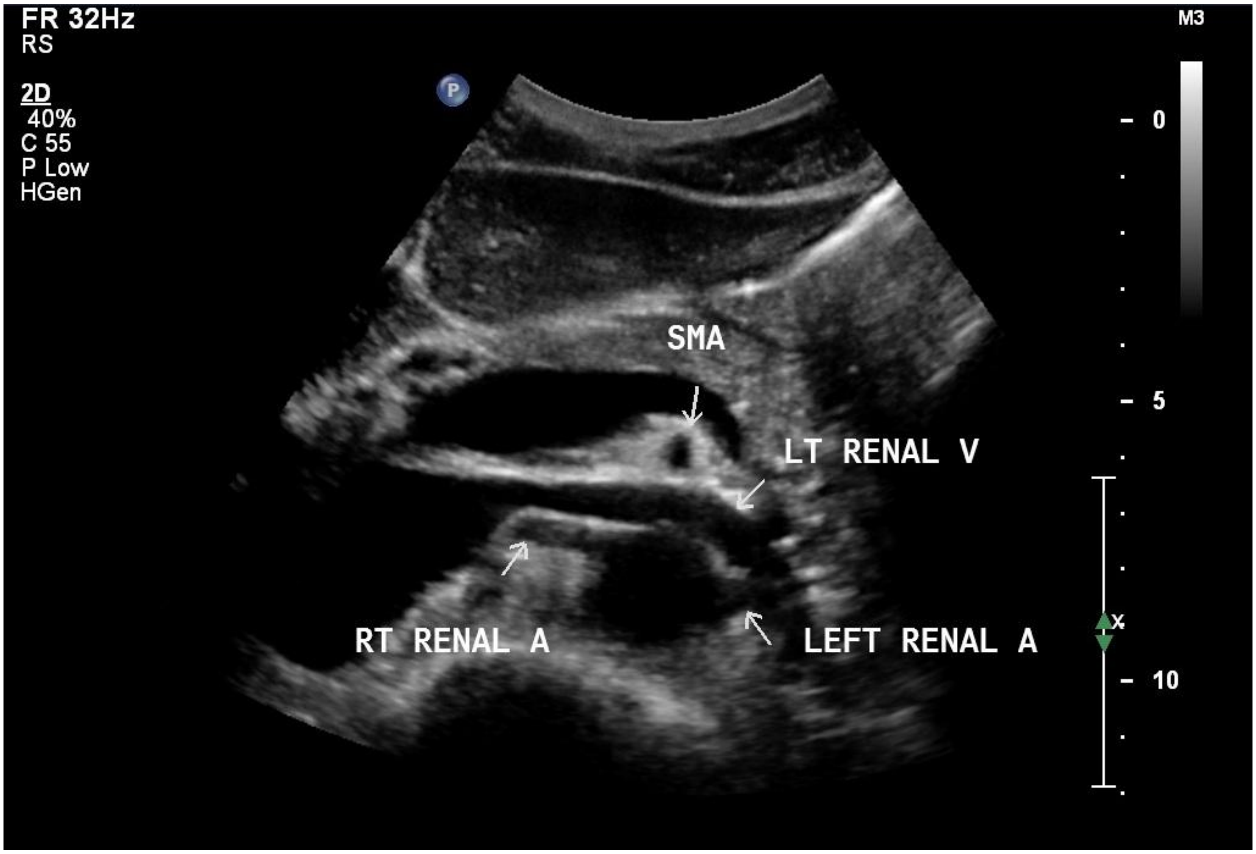
Figure 1: Longitudinal image of the abdominal aorta at the level of the celiac artery and superior mesenteric artery. The celiac artery is the first major artery to arise from the abdominal aorta just below the diaphragm at about the level of T12. Its course is more perpendicular to the aorta than the SMA (second major branch), which tends to run parallel to the aorta.

Figure 2: Transverse image of the aorta at the level of the celiac artery as it divides into the hepatic and splenic arteries demonstrating the “seagull sign”.



3. The second major vessel is the superior mesenteric artery (SMA), which arises anteriorly and about 1 cm inferior to the celiac artery. It angles anteriorly and inferiorly then courses inferiorly and parallel to the abdominal aorta. **(See Figure 1.)**
4. The next major vessels are the renal arteries, which usually arise 1 cm inferior to the SMA and are seen best in the transverse plane. They arise laterally. However they can arise slightly anteriorly (right) or posteriorly (left) from direct lateral. The right renal artery is longer than the left and normally arises slightly anterior to direct lateral then courses behind the IVC. **(See Figure 3.)**

Figure 3: Transverse image of the abdominal aorta at the level of the renal arteries. The renal arteries generally arise 1 cm below the SMA, however can be variable. There can be multiple renal arteries on either side, in which case the accessory renal arteries may arise closer to the SMA or further down (distal) to the main renal arteries. The diameter measurements at this level should be taken 2 cm inferior to the lowest main renal artery.



5. The aortic bifurcation is generally at L4-5 or based on external landmarks, at approximately the level of the umbilicus or just below it.

ii. Differentiation between the IVC and the abdominal aorta

1. The inferior vena cava lies to the right of midline. It is compressible, has thinner walls, and its flow waveform has respiratory variation on Doppler interrogation. It is usually large, which is dependent on the state of hydration, and non pulsatile, unless there is pronounced tricuspid valve regurgitation or markedly elevated right heart pressures. The waveform will almost always reflect flow changes secondary to changes in the right atrial pressures and filling.
2. The abdominal aorta is to the left of midline, is non-compressible, has thick walls and no respiratory variation. It is pulsatile and is usually smaller than the IVC, unless there is an AAA.

iii. Size criteria for normal and abnormal aortas

1. The average normal infrarenal abdominal aorta AP dimension is 2.0 cm just below the renal arteries and 1.5 cm at the bifurcation.
2. An "ectatic" aorta is defined as one in which the maximal diameter is 2.5 – 2.9 cm.
3. The majority of "aneurysmal" aortas are fusiform in contour and have a

maximal diameter of 3.0 cm or greater. The less common saccular aneurysm may measure less than 3 cm in diameter. **(See Figures 4-6.)**

4. Aortic dissections may be either normal in size or enlarged and have a characteristic intimal flap. **(See Figure 7.)**.

iv. 90% of the abdominal aortic aneurysms occur distal to the renal arteries.

Figure 4: Drawing demonstrating the difference between a fusiform (diffuse circumferential wall weakening) and a saccular (focal weakening of one side of the aorta) aneurysm.

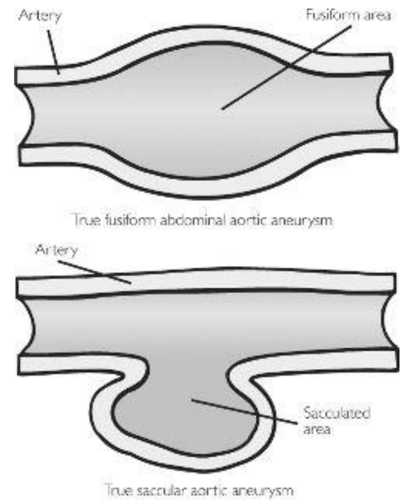


Figure 5: a) Color picture depicting an infrarenal AAA with a gray scale longitudinal image insert of the AAA containing thrombus. b) Transverse image of an AAA with thrombus.

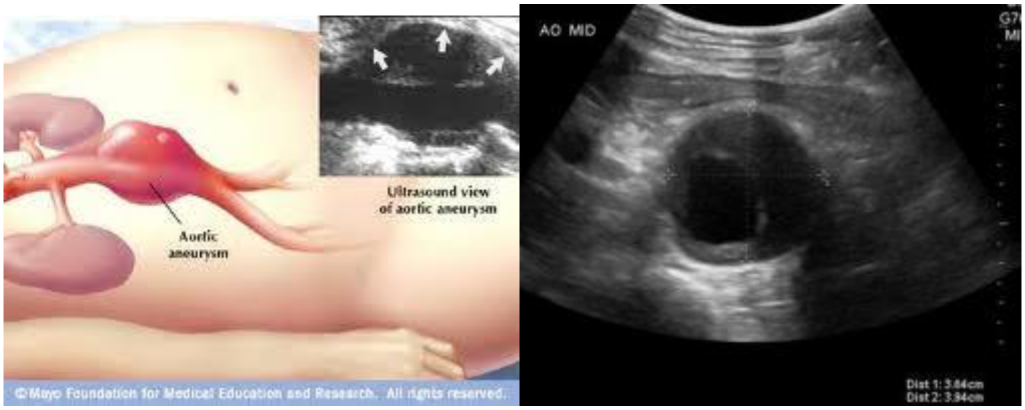


Figure 6: Longitudinal view of the infrarenal abdominal aorta with a focal anterior saccular aneurysm. Note that in this case the aneurysm is less than 3 cm in diameter.

Figure 7: Transverse image of the abdominal aorta with an ecchogenic flap from a dissection. Most abdominal aortic dissections extend inferiorly from the thoracic aorta. However with newer imaging technologies such as CT, MRI and ultrasonography more focal dissections have been seen in the infrarenal abdominal aorta.

f. Sonographic technique

i. Initially scan in both the transverse and longitudinal views to get an overall view of the aorta and its course, especially since the aorta can be quite tortuous.

1. Start in the transverse plane high in the epigastrium using the liver as a sonic window. Identify a vertebral body (a dark rounded shape with a bright rim around the anterior edge and a dense shadow). Identify the aorta to the left and the IVC to the right of midline and anterior to the vertebral body. Identify the celiac and superior mesenteric arteries and the aortic bifurcation to set the boundries of the abdominal aorta in your mind. Identify the renal arteries. Remember, the right renal artery will usually arise superior to the left, and that there is frequently more than one artery to a kidney.
2. Switch to the longitudinal view and again identify the celiac and superior mesenteric arteries and the aortic bifurcation to confirm the boundries of the abdominal aorta. **(See Figures 1 and 8.)** Use this view to get a better idea of any tortuousity.

ii. Use real time scanning so as not to miss focal saccular aneurysms or dissections.

iii. 1. CRITICAL POINT. Be sure that the aorta is imaged in a plane that is truly transverse to the aorta. Oblique views will overestimate the diameter. This is especially a problem with tortuous aortas and in limited acoustic windows. An image that is truly transverse to the aorta will be the image that is closest to a circular shape. As the shape becomes more oval, the plane is less transverse. The view that is transverse to the aorta may be nowhere close to transverse to the body.

2. Record on transverse imaging the AP (front to back) and transverse (side to side) diameters of the abdominal aorta at the following 4 levels:
   a. Proximal Aorta: Just below superior mesenteric artery. **(See Figure 9.)**

Figure 8: Longitudinal image of the abdominal aorta at the level of the mid and distal aorta demonstrating length and appearance of the aorta between the renal arteries and the aortic bifurcation. Make sure that the image plane is in the center of abdominal aorta.

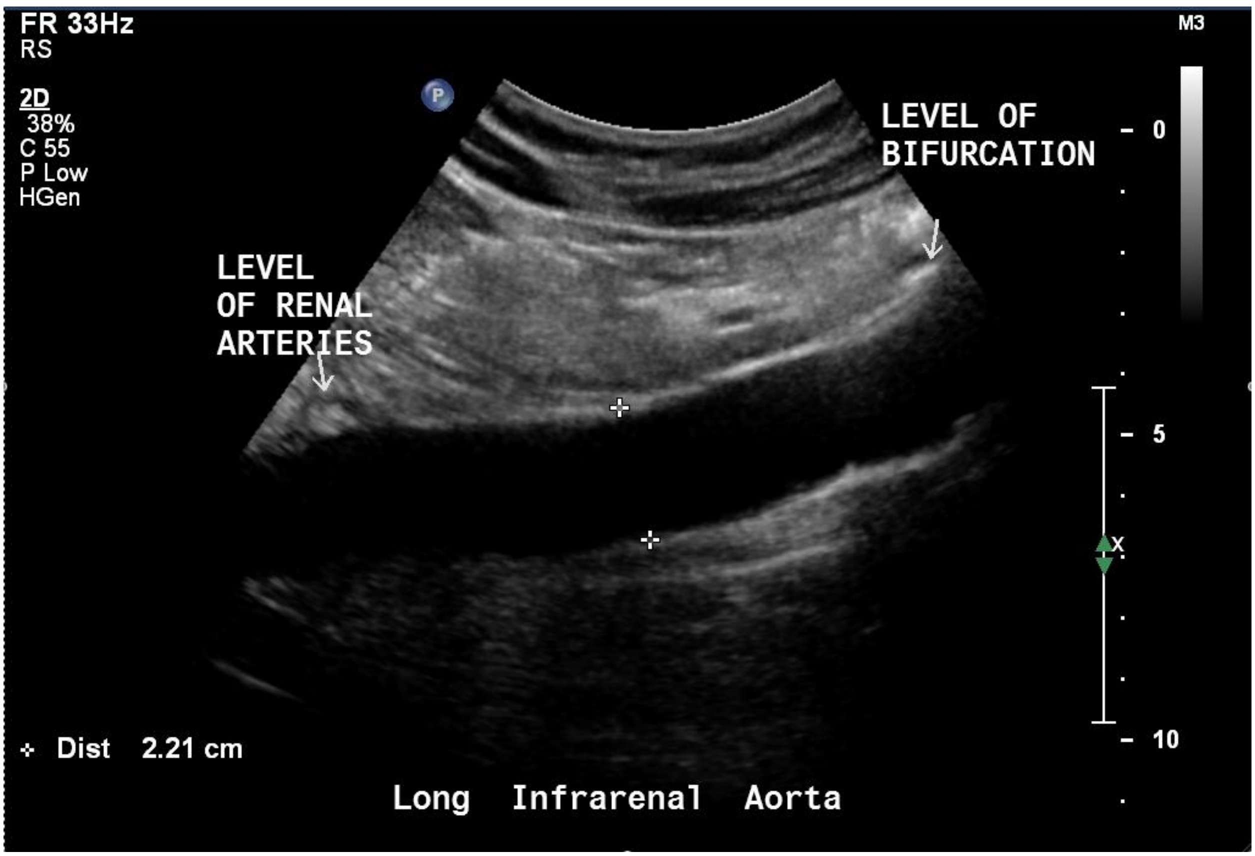
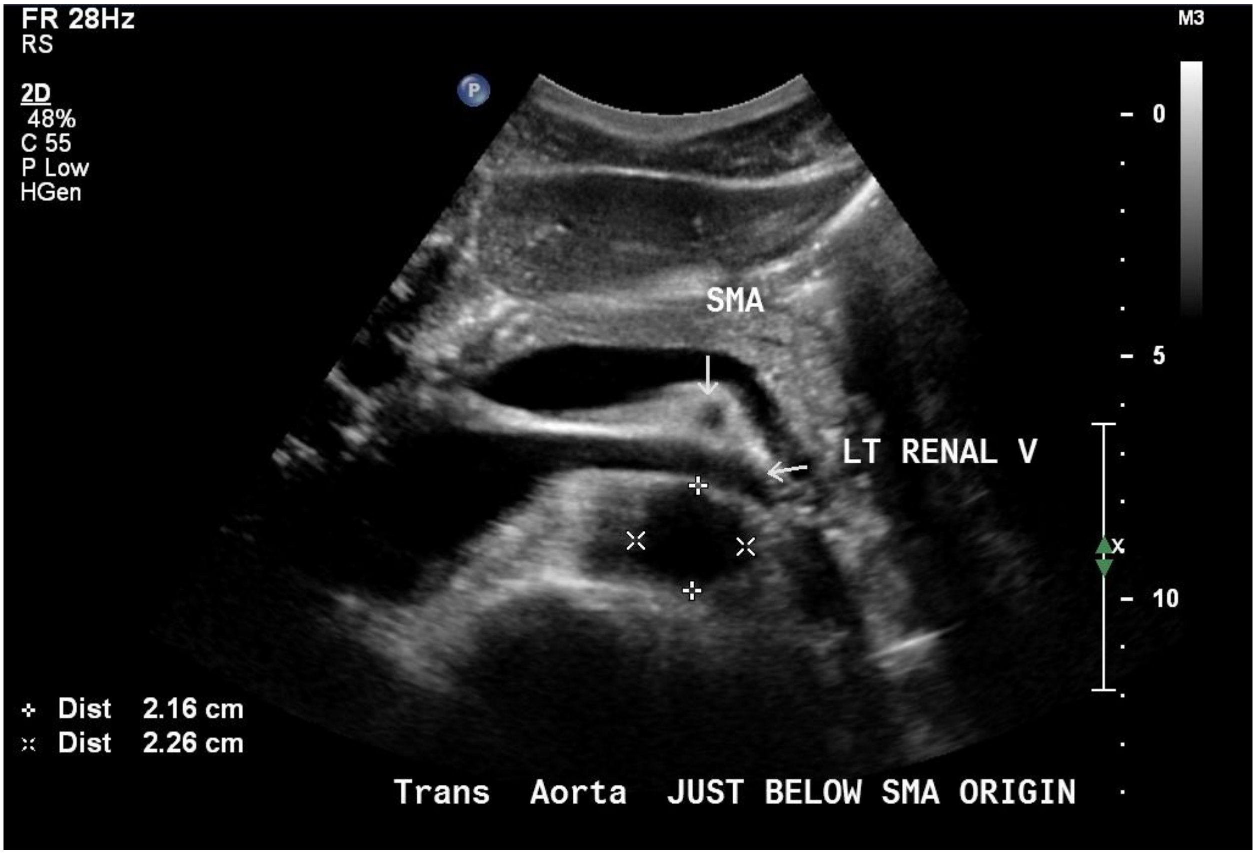


Figure 9: Transverse image of the infrarenal abdominal aorta just below the origin of the superior mesenteric artery. Measurements were taken of the AP and transverse diameters of the aorta at this level from outer wall to outer wall.



b. Mid Aorta: In the region 2 cm inferior to the lower of the renal arteries. **(See Figures 10 and 11.)**

Figure 10: Longitudinal image of the infrarenal abdominal aorta at the level of the renal arteries. The second group of measurements will be taken 2 cm inferior to the lowest main renal artery.

Figure 11: Transverse image of the abdominal aorta 2 cm below the renal arteries. AP and transverse diameter measurements were taken from outer wall to outer wall.

c. Distal Aorta: In the region just above the bifurcation. **(See Figures 12 and 13.)**

Figure 12: Longitudinal view of the aortic bifurcation scanning medially from the right lateral position demonstrating the aortic bifurcation and the 1 cm distance above the bifurcation where the transverse image should be obtained.

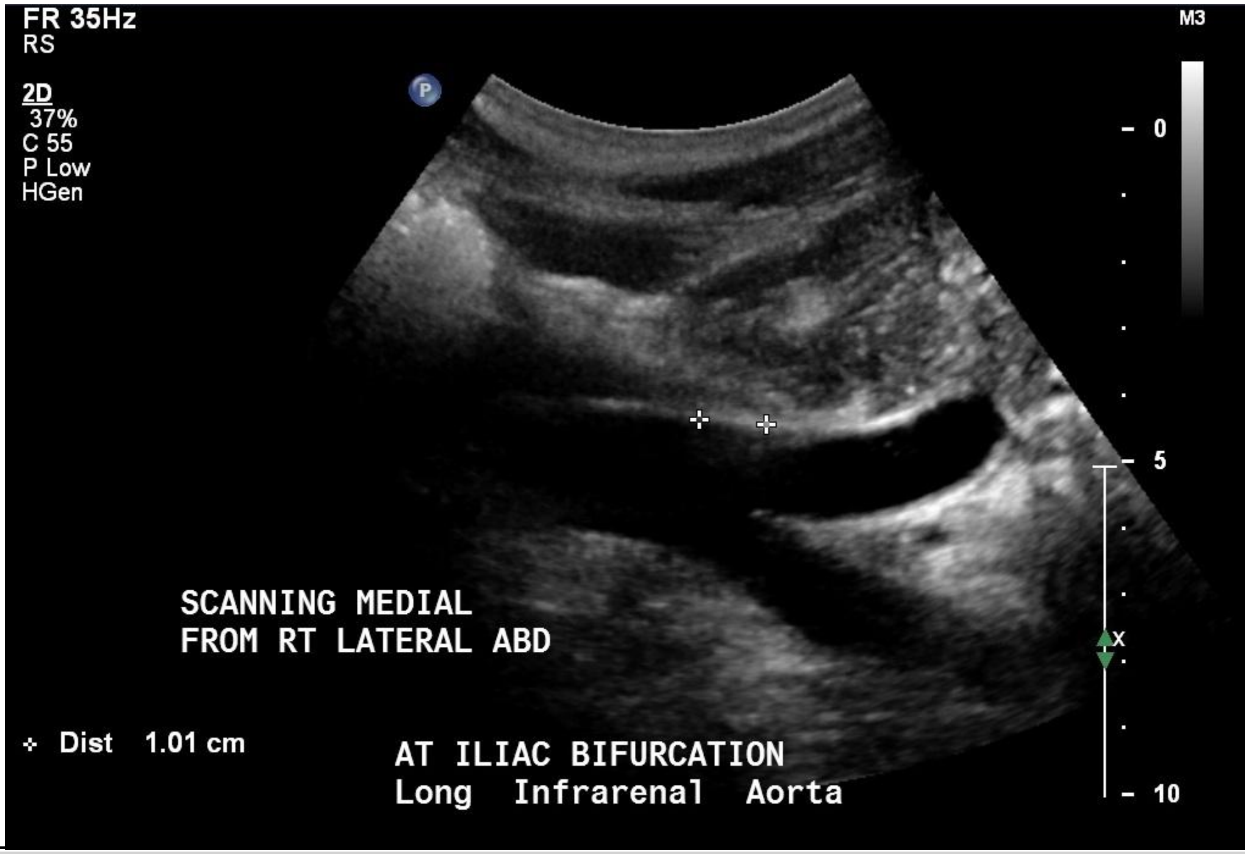
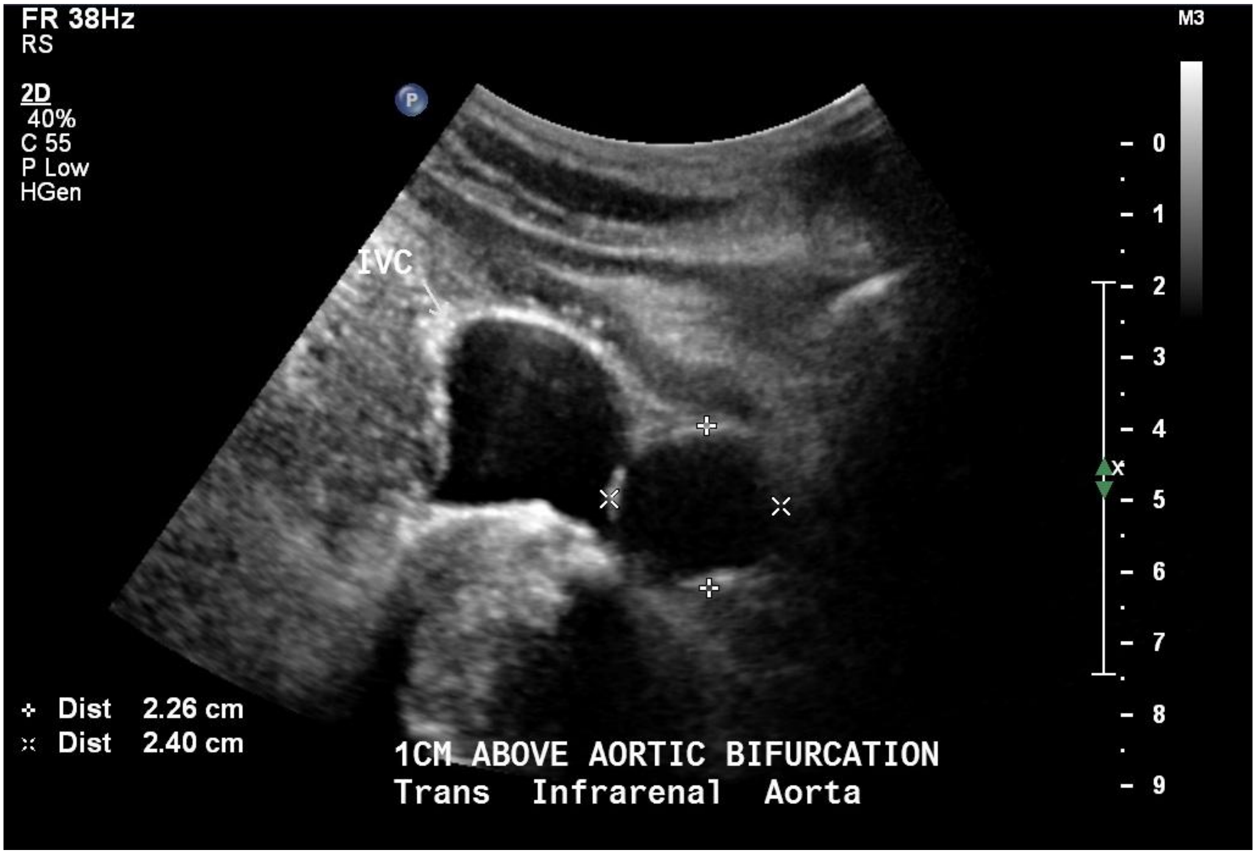


Figure 13: Transverse view of the infrarenal abdominal aorta 1 cm above the aortic bifurcation. AP and transverse diameters have been measured from outer wall to outer wall.



d. In the region of the largest transverse diameter if it is different than one of the 3 measurements above.
e. If there is potential AAA (>2.8 cm) present measure the maximal diameter in the AP and transverse dimensions.

3. Record on longitudinal imaging the entire abdominal aorta from the renal arteries to the bifurcation. **(See Figure 8.)**
   a. In order to see the entire abdominal aorta over this length, it may require more than one image if there is tortuousity.
   b. If there is a potential AAA present record the maximal AP diameter.
   c. Demonstrate clearly the relationship of the top of the potential AAA to the renal arteries, so that it is clear whether the aneurysm begins above, at, or below the renal arteries.
      i. If there is a difference, as there often is, between the origin of the arteries (the left is often inferior to the right), make sure that the more inferior artery is your primary target.

iv. If other arterial pathology is seen, record as appropriate.
   1. If there is any intraluminal thrombus, carefully demonstrate its extent on longitudinal and transverse images.
   2. Document any saccular aneurysms, dissections and ulcerations.

v. If there is non-vascular pathology, such as lymphadenopathy or periaortic masses, renal obstruction or adjacent fluid collections, document by imaging in both the transverse and longitudinal planes, and measure its dimensions and extent and whether there is blood flow present in the mass with color and Doppler examination. Record the non-vascular pathology on the AAA Technologist Data Collection Form.

vi. Sonographic technical tips

1. Gas filled loops of bowel can be a big problem. Don't give up without making an effort.
    a. As long as you push slowly, you can push fairly firmly and still not cause the participant pain. Sometimes just with pressure and patience the bowel loop will move out of the way, or its gas content will go elsewhere.
    b. Jiggling the probe while applying pressure sometimes allows the bowel to be gently moved aside.
    c. You can also move the probe until you find a sonographic window between loops of bowel. Once you find a window it is best to try to get images by just rocking the probe up and down without moving too far across the skin to maximize the information attained through this window.
    d. For the upper to mid aorta, one frequently identified sonic window is in the upper epigastrium where you can get the liver to become the window by having the participant take a deep breath.
    e. Another window for the mid to lower aorta is just above the umbilicus where the bowel loops are often quite mobile.
    f. Scanning from the left or right mid axillary line below the costal margin directing the probe slightly anteriorly can also afford a sonic window. The participant can be repositioned by rolling them so they are lying on their left side and then scanning from the right subcostal approach using the liver as an acoustic window.
2. For visualization problems at the aortic bifurcation, try to use an oblique angle with the probe placed lateral to the umbilicus on either the left or right, and pointing toward the spinal column.

g. AAA Technologist Data Collection

As images are taken, record the aortic diameters on the AAA Technologist Data Collection Form. Generally, the Technologist Data Collection Form will be completed on paper and entered into the ARIC data management system after the participant leaves. The presence of an AAT form in the DMS is an indication that an Aortic ultrasound was undertaken (complete or partial scan). This form should only be missing if the ultrasound was not attempted, for example due to an exclusion on the Participant Safety Screen (PSA).

i. Record from the images onto diameters part of the Data Collection Form the AP and transverse diameters of the abdominal aorta at the levels previously mentioned. Be sure to capture any potential AAA.

ii. Record the dimensions and characteristics of any possible non-vascular pathology on the "Abnormal" part of the Data Collection Form.

iv. If you can not see a section of the aorta, likely due to bowel gas, MAKE SURE that you take an image of the bowel gas and whatever else is visible, and then put the code "9.9" in boxes where the AP and transverse measurements would usually go. Even if most of an attempted scan is obscured and diameters are 9.9, please complete the AAT form and submit the images to the AICL.

h. Emergencies

In the unlikely event that the participant appears to have ANY life-threatening problem (rupture or dissection), they should be sent to the emergency room for a

more complete evaluation. This is recorded on Form items 5 to 7.
Signs of possible rupture are tenderness, and fluid OUTSIDE of the wall of the aorta, particularly if there appears to be a flow signal from the fluid.
Dissection often is associated with abdominal or back pain.

i. Findings Warranting Quick Over-Reading
If the participant appears to have a finding (listed in iv below) that warrants an ASAP interpretation by the University of Minnesota Aortic Imaging Core Lab (UMN AICL), the field technologist shall email the three AICL readers (i to iii listed below) to alert a reader to the study in question. A reader will send an email reply. If no reply is received within 24 hours, the technologist shall call or page one of the readers. If there still is no response, the technologist should contact the UMN AICL Coordinator, Jingying Lin <linxx634@umn.edu>. In addition, the tech must contact the Echo Reading Center to forward the images to the AICL as soon as possible. The alert action is also recorded under Form items 6 and 7.
   i. Dr. David Hunter:
      Pager: 612-899-7349
      Phone: 612-626-5570
      Email: hunte001@umn.edu
   ii. Dr. Carol Steenson
      Pager: 612-818-7011
      Phone: 612-725-2038
      Email: ccsteenson@gmail.com
   iii. Dr. Emil Missov
      Pager: 612-899-7702
      Phone: 612-624-6132
      Email: misso001@umn.edu
   iv. Notification criteria
      1. AAA > 5.0 cm
      2. Nonvascular finding such as an unknown periaortic mass
      3. Vascular finding of uncertain significance or pathology
      4. Other question or problem

j. Discussion of findings with participants
Avoid discussions of findings with participants unless you have the permission of your Field Center's physician.

4. Sonographer Training and Certification

a. Sonographer training
   i. The sonographer will have completed the training for the cardiac component of the study and will be familiar with the ultrasound equipment.
   ii. During the centralized training session for echocardiography, one day will be set aside to address the AAA screening examination. One UMN AICL radiologist and application specialists familiar with AAA examinations will provide the instruction. Training will consist of a review of the protocol followed by a hands on session for each ARIC technologist using the volunteers from the cardiac training. The ARIC technologists will have already been trained in transmitting the images. Training will include how to complete the AAA Technologist Data Collection Form on paper. Training on entering the Form into the ARIC Data Management System will take place at the field center.

b. Reference materials

   i. The Field Center Manual of Operations containing the protocol, required views and the Data Collection Form for the AAA screening will be provided.

c. Monitoring
   i. The UMN AICL will monitor the submitted examinations for their adequacy and quality. Any deficits will be reported to the Coordinating Center who will transmit to the Field Center. Any pattern of inadequacy or poor quality studies will be addressed with the technologist and Field Center Principal Investigator.

d. Sonographer Certification
   i. Before the ARIC Visit 5 pilot test, each sonographer will submit two certification studies performed in accordance with the protocol described in this manual and transferred electronically to the UMN AICL for review and certification.
   ii. Studies will be evaluated for adherence to the protocol, acquisition of all required views and image quality. Sonographers will have the opportunity to re submit an examination if an initial study is inadequate. Once the sonographer has submitted 2 adequate studies they will be certified and will be notified of the certification.
   iii. New field sonographers starting during the study will have to undergo the same certification process.
   iv. The AICL will perform periodic site visits to observe Field Center sonographers.

5. Image and Data Transfer

a. The Echo Reading Center has set up the data transfer mechanism between field sites and the UMN AICL.

b. All aortic ultrasound scans are transferred. The Coordinating Center will identify any abdominal aorta measuring 2.8 cm or more or with alert pathology for AICL reading. In addition, a random 5% of presumed normal studies will be identified for over reading and QA.

6. Reporting Findings by the UMN AICL

a. AAA screening images will be transmitted to the AICL using standard DICOM transfer techniques. The ARIC Coordinating Center will select the sample of images for reading and send the IDs to the UMN AICL.

b. AAA Over-Reader Data Collection Forms will be completed online and accessed on the ARIC Coordinating Center website.

c. If a field center technologist notified the AICL of a possible urgent finding (Section 3i), then the AICL will read the images and report ASAP. All other readings are targeted for completion in 2 weeks.

d. These studies are performed to obtain aortic size measures in an elderly community-based cohort. There are several limitations to the studies: the studies are not clinically indicated and a comprehensive study is not being performed. Additionally, the UMN AICL will be reviewing studies in the absence of any clinical information. For these reasons, UMN AICL adjudication of ARIC study aortic ultrasounds will not and cannot be equivalent to a clinically acquired and interpreted aortic ultrasound.

e. Findings to be reported to the ARIC Coordinating Center and to go into letters to participants and their physicians.

Summary of ARIC Aortic Reports

Report Category	Finding		Report Statement
Urgent/ Alert	AAA>5.0 cm Periaortic mass Other alert pathology	Pt	"Your aortic ultrasound showed a _______, which is a serious abnormality. The maximum aortic diameter was _______ centimeters. Please contact your physician soon for further evaluation."
		MD	"Your patient's aortic ultrasound showed a _______. The maximum aortic diameter was _______ cm. We asked him/her to contact your office soon for further evaluation, for example, a clinical scan."
Abnormal	AAA 3.0-5.0 cm Saccular aneurysm Aortic thrombus Other clinically relevant pathology	Pt	"Your aortic ultrasound showed a _______. The maximum aortic diameter was _______ centimeters. You should follow-up with your physician within a month."
		MD	"Your patient's aortic ultrasound showed a _______. The maximum aortic diameter was _______ cm. We asked him/her to contact your office within a month for further evaluation, for example, a clinical scan."
Normal	No aneurysm or clinically relevant pathology	Pt	"Your aortic ultrasound was normal or showed no clinically relevant finding. Your maximum aortic diameter was _______ centimeters."
		MD	"Your patient's aortic ultrasound was normal or showed no clinically relevant finding. His/her maximum aortic diameter was _______ cm."

7. Quality Assurance Plan

a. Start-up phase, which begins after the 2-study certification is completed.
    i. Each field sonographer will send their first 5 studies to the UMN AICL for evaluation
    ii. A written evaluation will be provided.
    iii. Any systematic errors will be evaluated on the following 5 studies.
b. Study period

i. Technologist
   a, All studies on which an aortic diameter ≥ 2.8 cm or other pathology is identified will be evaluated at the UMN AICL.
   b. 5 percent of all normal studies (maximal abdominal aortic diameter < 2.8 cm) will be sent to the UMN AICL for evaluation.
   c. Any errors will be documented and discussed with the technologist.
   d. Further evaluation of the studies of any technologist who is having problems will then be done at the direction of Drs. Steenson, Hunter, or Missov at the UMN AICL.

ii. Over-readers
   a. Over-readers will calibrate with each other at study onset.
   b. The ARIC Coordinating Center will send blind repeats for reader QC throughout.

8. Data Notes for the ARIC Coordinating Center (CSCC)

a. Field centers will complete the AAA Technologist Data Collection (AAT) Form.

b. Field Centers will record DICOM images to correspond to the AAT form items.

c. AICL needs to store the AAT data and the images when received. In addition, CSCC needs to identify IDs for any abnormals and 5% random (or systematic) sample of normals and notify the AICL.

   i. CSCC is also expected to put the AAT on their website, so AICL can retrieve it and the images together. The AAT view should be identical to the paper version. CSCC also must make the corresponding blank AAA Over-Reader Data Collection (AAO) Form simultaneously retrievable. UMN readers have multiple computer screens, so for a single ARIC ID they can review both elements (AAT and images) and enter AAO, altogether.

d. UMN Over-Readers complete the AAO form on the web and submit it to CSCC.
   i. If a diameter is incorrect on the AAT, the Over-Readers will re-measure or re-read the image and insert corrected values into Sections I and II of the AAO.
   ii. CSCC can use Section III of the AAO directly for Result Letter statements to participants and their MDs. The results letters will also include the maximum aortic diameter for each participant. Maximum will be defined for Normal participants not over-read by UMN as the greatest diameter on the AAT. Maximum will be defined for Over-Read scans with the MD box checked as "Normal" as the greatest diameter on in Section 1 or 2 of the AAT, unless corrected by the Over-Reader MD; in that case, the greatest value on the AAT or AAO is taken. The same approach is used to capture the maximum diameter for scans over-read as "Abnormal or Alerts" on the AAO.
   iii. The CSCC will transmit regular Quality Reports to Field Center technologists, coordinators, and PIs based on items recorded in Section IV of the AAO.

e. Final continuous aortic continuous data for analysis and hypothesis testing will come from a combination of values from the AAT and AAO forms. The final AAA=yes definition shall be an AAA >=5 cm or 3.0-4.9 cm as recorded in the Results section of the AAO form. Saccular aneurysms and other abnormalities are also captured from the AAO.

9. Clarifications to Protocol After Visit 5 Started

a. From Dr. Hunter:

I would always start with a longitudinal view and take 2 pictures of the abdominal aorta, one of the proximal aorta (labelled Long Prox Ao), which clearly demonstrates the origin of the superior mesenteric artery and often the celiac artery; and then a 2nd view of the distal abdominal aorta (labelled Long Dist Ao) looking as far down towards the bifurcation as possible. In order to see these views, it may be necessary to move the transducer off the portion of the abdomen that is directly above the aorta so that you can get a clear view around gas.
This will also be a good time to test how hard of a "push" the patient will tolerate in order to attempt to move gas. Gas moves best with slow, steady, firm compression so patient tolerance is always an issue. You can at this point also optimize your settings in terms of the time gain compensation, and positioning of the aorta approximately 2/3 the way down the image.

After you have clearly identified the aorta, which process can of course be assisted especially for deep aortas with the use of color-flow imaging, I would then position myself at the origin of the superior mesenteric artery and turn the transducer into the transverse position for the proximal aorta transverse view. This view should always include both the aorta and a transverse view of the superior mesenteric artery just superficial to the aorta. If at all possible, I would try to include both the aorta and the inferior vena cava in all 3 of the required transverse images. This will help you and us to make sure that you are evaluating the correct vessel, particularly when those vessels are very deep. When measuring the aorta diameters in the AP and transverse directions, try to think of the aortic wall as being between 1.5 and 2.5 mm thick. It is usually slightly thicker anteriorly, and is, of course, a little thicker for patients who have more atherosclerosis.
Nonetheless, I would almost never put the cursor more than 2.5 mm away from the inner wall of the aorta. The media and intima are occasionally marked by calcification and you can use the outside of the calcification as the position for the outer portion of the wall. Otherwise, it's a little bit of a guess, particularly on the lateral walls since they are always less clear than the anterior and posterior walls, and you will just have to use your judgement. Nonetheless, don't put the cursor immediately adjacent to the inner wall since that will always give you measurements that are slightly too small.

Once you have made the measurements, set up a scheme in your head that you repeat every time so that you enter the AP measurement in the AP box on the form, and the transverse measurement in the transverse box. These measurements get flipped not infrequently, which may be due to the fact that the order they appear on your screen is different than the order they are on the form. However, if you establish a routine, eventually you should get it right every time.

Another important thing to remember is that the only part of the aorta which matters for evaluating a patient for an "abdominal aortic aneurysm" is the INFRARENAL aorta. Therefore, the measurements that you make of the "proximal aorta" do NOT MATTER at all, except for research purposes. The only measurements which are of concern in terms of calling the study "abnormal" or "normal" are the measurements of the mid and distal aorta. You should be calling any study "abnormal" if either of these 2 sites has a measurement, either AP or transverse, that is greater than 2.8 cm. When we read the study, we will often change your "abnormal" grade to a grade of "normal" because the largest diameter is not equal to or greater than 3.0 cm which is the actual size that we are using to call something an "aneurysm". Nonetheless, just to make sure that we never make a mistake and miss one, we are asking you to call anything abnormal that is greater than 2.8 cm.

You will notice that line "3g" asks for the "maximal aortic diameter".
This can be confusing since often that maximal diameter is up in the proximal aorta. However, 3g is ONLY used for a "maximal diameter" if that maximal diameter is located in the INFRARENAL AORTA, and if that maximal diameter is not already matched by one of the 4 diameters that you have recorded for the mid and distal aorta. If you do find an area of the infrarenal abdominal aorta that is separate from the mid and distal areas that you already filmed and measured, where there is a "larger diameter" than any of the 4 that you have already entered, then you do have to take a "picture" of that larger section, and also you have to enter the AP and transverse measurements into 3g. Otherwise, 3g should be left blank.

You can use slight degrees of left-right obliquity and pressure from your transducer to move gas out of the way so that you can get a good transverse measurement. As long as you are at the correct level, the exact right or left angle that you used to interrogate the aorta is not particularly important. I would avoid compressing the aorta to such an extent that you change its shape, but this should really be difficult to do and should not usually be an issue. Also, be sure not to tilt the transducer so that you are looking inferiorly or superiorly in order to see the aorta since that will give you an oblique measurement that will be "too long" in the AP direction. Many of you may note, if you go back and look at studies you have done, that the AP measurement has been larger than the transverse measurement. Whenever this occurs, ask yourself if you have taken an image which is angled up or down. Usually, you can expect that the AP and transverse measurements will either be equal or that the transverse measurement will be slightly larger (gravity will have its way with all of us eventually). Obviously, in cases with an aneurysm or even bad atherosclerosis, the AP and transverse measurements can be whatever they want.

b. From Drs. Hunter and Steenson regarding atherosclerotic plaques:

We expect that most of the ARIC subjects will have atherosclerotic plaques of different degrees of severity throughout their abdominal aorta. This is particularly true in any patient who has coronary artery disease, which will obviously be common in this study population. In general, we will not call these “alerts” or even abnormal unless a plaque is significant enough to compromise the lumen by approximately 50%, or has a very inhomogeneous appearance, particularly with a visible ulcer that contains clot. Even then, this would only require notification of the primary physician, not an "urgent alert". If a plaque compromises the lumen by greater than 90%, the patient at that point should by all rights be symptomatic and some type of “urgent alert” would be appropriate.

The techs can flag aortic plaques on the AAT form, item 5d “Other Aortic Findings,” if the plaque is has the above characteristics or other unusual appearance. Small plaques need not be flagged.