How to Run a Stress Test

1) SPECT Stress Tests
   a) Exercise
      i) Contraindications:

Table 1. Contraindications to Exercise Testing	
Absolute	**Relative[2]**
Acute myocardial infarction (within 2 d)	Left main coronary stenosis
Unstable angina not previously stabilized by medical therapy[1]	Moderate stenotic valvular heart disease
Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise	Electrolyte abnormalities
Symptomatic severe aortic stenosis	Severe arterial hypertension[3]
Uncontrolled symptomatic heart failure	Tachyarrhythmias or bradyarrhythmias
Acute pulmonary embolus or pulmonary infarction	Hypertrophic cardiomyopathy and other forms of outflow tract obstruction
Acute myocarditis or pericarditis	Mental or physical impairment leading to inability to exercise adequately
Acute aortic dissection	High-degree atrioventricular block

      ii) Choose Bruce protocol vs modified Bruce protocol
         (1) Modified Bruce just means that the patient with have two stage 1 rounds (very elderly or sedentary patients)
      iii) To start the test, have patient step on the treadmill.
         (1) Push start treadmill on right hand side, then exercise button on left hand side. ECGs will print automatically.
      iv) Measure BP every 2 minutes (record by pushing BP button)
      v) Have patient exercise as long as they can, ideally at least until they can achieve maximum HR (220-age).
         (1) Have nuclear tech inject radiotracer 30 seconds prior to having the patient stop exercising.
         (2) If patient does not achieve maximum heart rate, convert test into low intensity exercise + pharm (as below)
      vi) 30-60 seconds after radiotracer is injected, stop the treadmill.
      vii) End the test (end test button) and input the following:
         (1) Bruce protocol/modified Bruce protocol/low intensity pharmacologic/pharmacologic stress test performed. Hemodynamic response to exercise ***. If Bruce/modified Bruce: report limiting symptoms, calculate FAI (https://faculty.washington.edu/dtlinker/FAI3/)
         (2) Baseline ECG revealed ***. There were no ischemic ECG changes (or document ECG changes). Symptoms of vasodilator *** resolved spontaneously/with 75mg aminophylline.
         (3) Perfusion images will be reported separately
         (4) Preliminary ECG interpretation by *** (your name)
   b) Low intensity exercise + pharm
      i) This test involves having the patient walk on the treadmill for 1 minute, injecting the pharmacologic stress agent (regadenoson unless contraindication) and then walking for 5-6 minutes after rega has been injected.
      ii) To start the test, have patient step on the treadmill.
         (1) Push start treadmill on right hand side, then exercise button on left hand side. ECGs will print automatically.
         (2) Choose comfortable walking speed for the patient (does not matter what speed your chose)

        iii) After 1 minute of walking, ask the nuclear tech to inject the pharmacologic stress agent. They will inject the radiotracer 1 minute afterward injecting the stress agent

        iv) Have patient walk for 5-6 minutes after regadenoson is injected

           (1) Monitor BP every 2 minutes, record by hitting BP button

        v) End test, input the same info as above

   c) Sitting pharm

        i) Choose this stress test for patients who are unable to walk at all

        ii) Have patient sit

        iii) Ask nuclear tech to inject pharmacologic stress agent. They will inject radiotracer 1 minute after pharmacologic stress agent is injected.

        iv) Monitor for ~ 5 minutes with BP measurements q2min

        v) End test, input same info as above.

2) PET Stress Tests

   a) There is no exercise portion of this. It is always pharmacologic. You will be responsible for monitoring the BP and heart rate after regadenoson is given and images are being obtained.

   b) Once test is over (nuclear techs will let you know) end the test the same way you would a stress SPECT as above.

3) Pharmacologic meds used

   a) Regadenoson (most common)

        i) Contraindications: second or third degree AVB in a patient without a PPM, severe reactive airway disease or active bronchoconstriction (can worsen bronchoconstriction), profound sinus bradycardia

        ii) Patient cannot have caffeine 12 hours prior to test (interacts with rega)

        iii) What to do if patient has significant side effect from regadenoson:

           (1) Give 75mg aminophylline – ideally this would be given at least 5 minutes after the radiotracer has been injected (6 minutes after regadenoson injected) otherwise it might not be a diagnostic study

              (a) If at least 5 minutes have passed as above, giving this medication will not impact the quality of your test, you can give for any reason (patient has severe nausea, shortness of breath, headache, etc.)

              (b) Contraindications: Allergy to medication, epilepsy (can trigger seizures)

           (2) Can give a second dose if needed 10-15 minutes apart from the first dose

   b) Dobutamine

        i) I never saw this used; I'm guessing I would be similar to echo stress tests.

Rest/Stress Cardiac SPECT or PET Image Processing on Cedars

1) If Cedars computer is off or logged off, turn on, and log in as user admin, password not needed

2) Open CSI (Cedars Sinai Imaging) program on desktop. Username: admin, Password: [leave blank], click "OK".

3) In the CSI program set Study Date filter to "Today" (or whatever the time range you need is). You should see a list of patients.
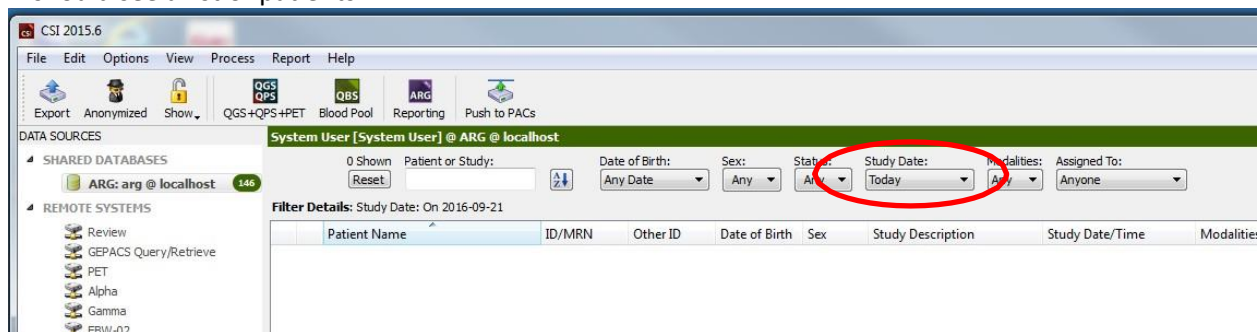
4) Select the patient of interest and their image series will be listed at the bottom half of the window. Techs will preprocess the studies and save their work. The two signals that a patient is ready for you to review are 1) You will be given physical paperwork for that patient and 2) There will be a "QGS QPS RESULTS" series listed for that patent in CSI along with their image series. (Don't open the analysis software for a patient before this saved results series appears because if the same patient is open in two windows, on your machine and on the tech's machine, whoever saves last overwrites the other one's work).
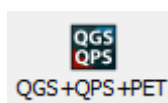
5) When ready to proceed, click . By default, all image series are loaded, which is generally what you want. If you need to restrict which image series are loaded, you can individually select the ones you want by Ctrl-clicking those studies and then clicking the QGS/QPS button.

6) The first step in the QGS/QPS window is a quality check, but it differs between SPECT and PET studies. For SPECT, click "Raw" and view the spins to ensure that there was not significant patient motion during the acquisition (visible as jumps in position in the spins).
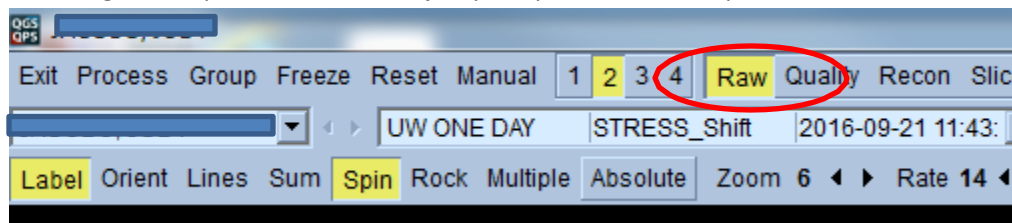

For PET, click "Fusion" and evaluate the alignment between the PET image and the corresponding CT image that was used for attenuation correction. Pay particular attention to

the lateral wall, as a misalignment here can cause an attenuation correction artifact which looks like a perfusion defect. Left clicking and dragging on the PET or CT images will scroll through the image series in the other two slicing planes, and right clicking on the PET or CT image will show a box of the other series overlaid. If there is an alignment error, there is not a way to adjust the alignment within Cedars, but the techs can re-align and re-send to Cedars. Once aligned, proceed.

7) Next select Splash to look at the short axis and horizontal and vertical long axis images.
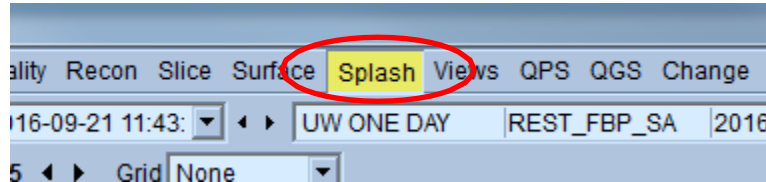
8) Make sure that the static Stress image is selected in the first image series selector (on the left, representing the top row of images), the static Rest image is selected in the second image series selector (in the middle, representing the second row of images), and that no image series ("---") is selected in the third image series selector (on the right, just improves image spacing and readability). Images are always read as Stress on top and Rest on the bottom, so double check that you have this correct.
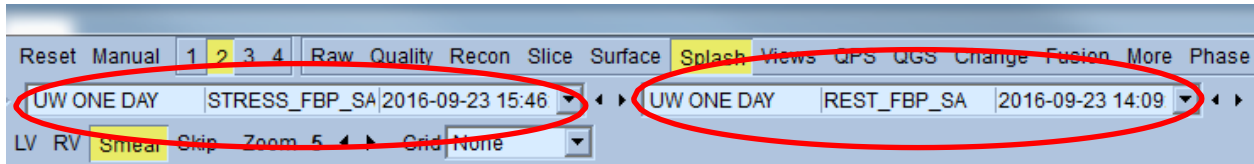
9) Next, adjust the colormap so that the rest and stress images are correctly normalized. Click on the dropdown arrow to the right of the colormap.
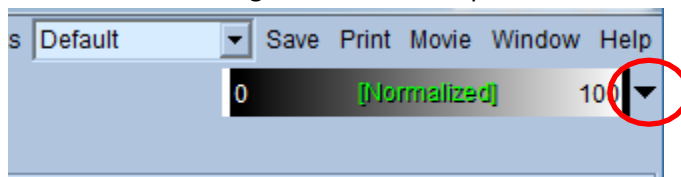
Change the colormap to "Step10", then click "Expand", then click "Split". There will now be three color bars, one for each series (stress, rest, blank). Adjust the left-most color bar (for Stress) by grabbing the black bar at the right of the color bar and dragging it until there is only a small region of white (the hottest color). Then adjust the middle color bar (for Rest) until there is only a similar small region of white. Then click the dropdown arrow on each of those colormaps and change the colormap to "Cool".

10) The images are now ready for assessment for perfusion defects. Focusing on stress SA image set, describe one by one each region of reduced radiotracer uptake following the below algorithm:
   a) Confirm the finding using a second view VLA or HLA.
   b) The size of the abnormality (small size, moderate size, large size)
      i) 1-2 segments = small

     ii) 3-4 segments = moderate

     iii) >4 segments = large

c) The severity of the abnormality (mild reduction, moderate reduction, severe reduction) --> always seemed rather subjective

d) The location and extent of the abnormality (entire anterior wall, basal ½ of the inferior wall, etc)

e) Is the abnormality present on the rest images (reversible = ischemia, fixed = attenuation versus infarction)

11) Next, assess wall motion. To do this you will need to change the image series selectors to choose the stress gated (on the left) and rest gated (in the middle) image series. On the selector dropdown, on the right-hand side, note that each series is labeled as stress or rest and as static or gated.
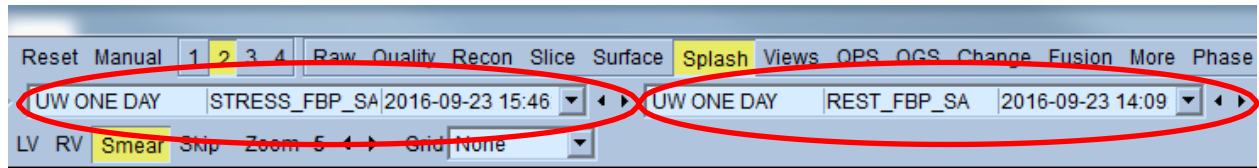
12) Next select the Gate toggle button to animate the gated images and assess wall motion.
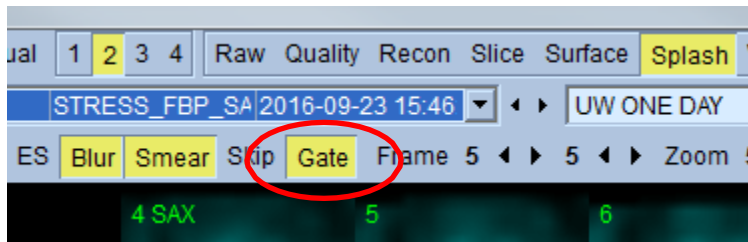
13) The Rest and Stress EF, as well as TID measurements will be displayed on the function panel to the right of the screen.
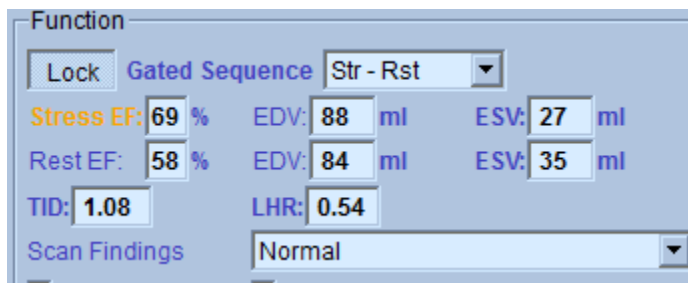
14) The last assessment step is to look at the polar map versions of the short axis static images on the QPS page.
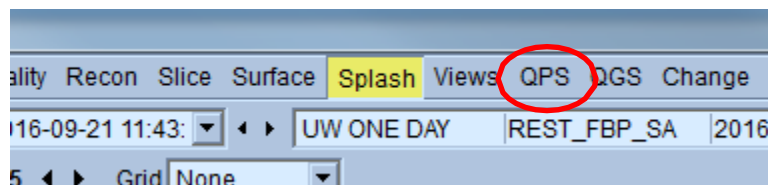
This page shows a polar map for stress, a polar map for rest, and a polar map for reversibility. Areas identified as defects based on a normal map are shown in black, and the reversibility map is just the black areas on the stress map minus the black areas on the rest map.

15) For PET Stress Tests Only

   a) Review the kinetics tab. This will report myocardial flow reserve, stress and rest flow reserve. This should be included in your final report.

      i) Normal myocardial flow reserve>1.8, normal stress flow >2.0

16) Go back to the Splash page, and begin entering reporting information on the right-hand side of the page. Generally, work your way from the top of the window to the bottom, filling in attending, then perfusion, then function information. Clicking on polar map segments increments the severity. Some areas which can be confusing are highlighted below:
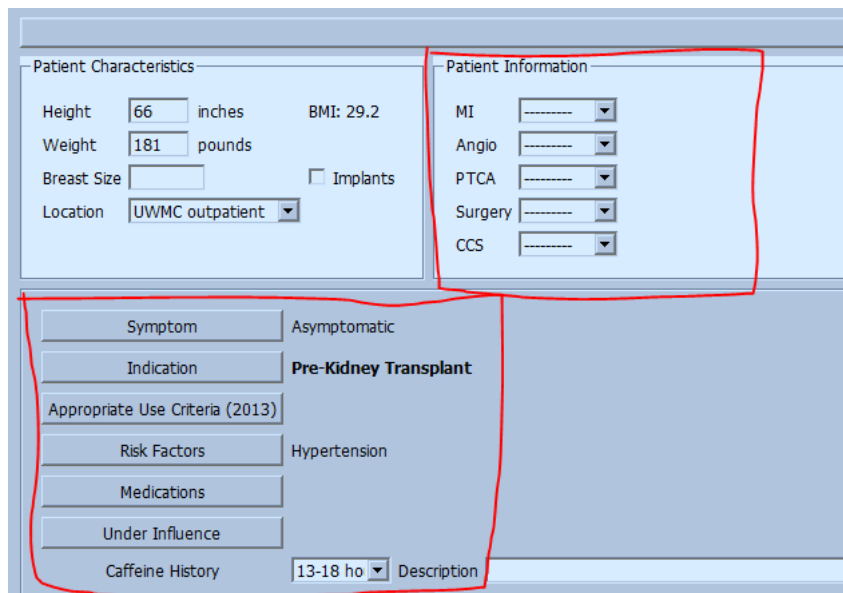
17) When you reach the bottom, click on the "Extended" button on the lower right.
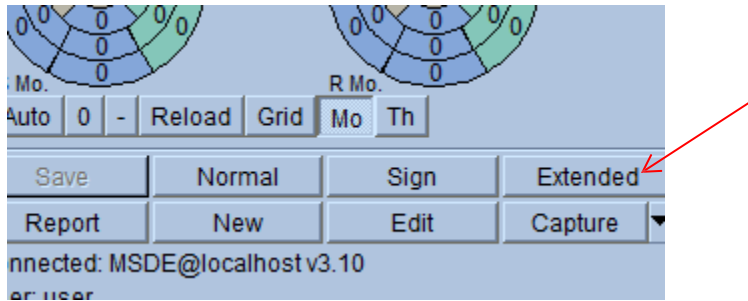
18) Fill out the Summary section using a template based on the test type and test results. Templates for the summary section start with "sum" or "summary", and contain "nl" for normal results and "abn" for abnormal results. Insert template text by double-clicking on the template in the list of templates on the right. Edit the template as needed. All text in the Summary section will appear at the end of the report.

19) Fill out the Additional Findings section. We use this section to report on artifacts, and all text in this section appears in the "Interpretations" section of the report, just before the summary section at the end. Templates for the additional findings section start with "add" in the template list. Templates are inserted at the current cursor position, so to get them to insert into the Additional Findings section, be sure to click in that area first.

20) Click on the History/ECG tab at the top. Working from top to bottom, fill in information as needed and relevant. We are not currently filling in the Appropriate Use Criteria, so it's OK to skip that; all other buttons in that section should be filled out (Symptoms, etc.). Note that hemodynamic information needs to be filled in near the radioisotope and dose information, but is off to the right, access that area by either expanding the window size or scrolling to the right at that point. Further down, fill out ECG findings, but since the official ECG report will come from Cardiology, do not select anyone as ECG physiologist or ECG Physician, but you can be listed as monitoring or supervising.

21) When you reach the bottom of the History/ECG tab, take a moment to look at the bottom of the window to see if there are any Errors or Warnings listed. These are potential inconsistencies the program has noticed in things you have entered. For example, if you mark a perfusion defect on the polar map, but selected that he scan findings were "Normal" then that would generate an Error which would be listed here. Going back and changing the findings to "Abnormal" would get rid of this error.

22) In rare cases, there may be errors or warnings which you do not feel are problems. In those cases, you can click the checkboxes to the left of the error or warning to acknowledge them, and then proceed.

23) Close the "Extended" window, and click the "Report" button to view the generated report.
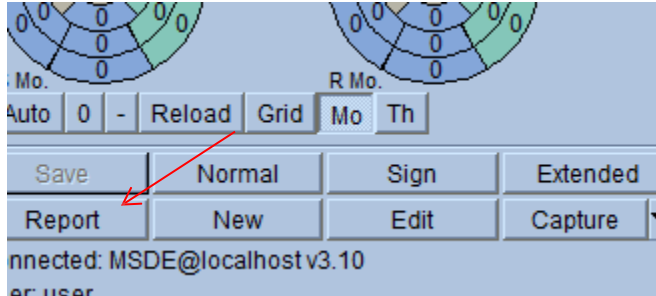
24) Click on the "Text" tab at the top of the Report window. Review the report text and, if needed, go back and make any changes necessary in the reporting interface (the report text is not directly editable). When you are satisfied with the report, select everything between the "Preview Only" lines (the first and last lines) and copy the text to the clipboard with Ctrl-C.

25) Exit out of the report and go back to the Splash images

a) Click Print (top right hand side of the screen) to send a screenshot of the splash images to Cedars
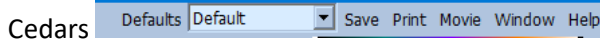
b) Ensure that you are in the Database tab NOT the File tab before selecting "OK"
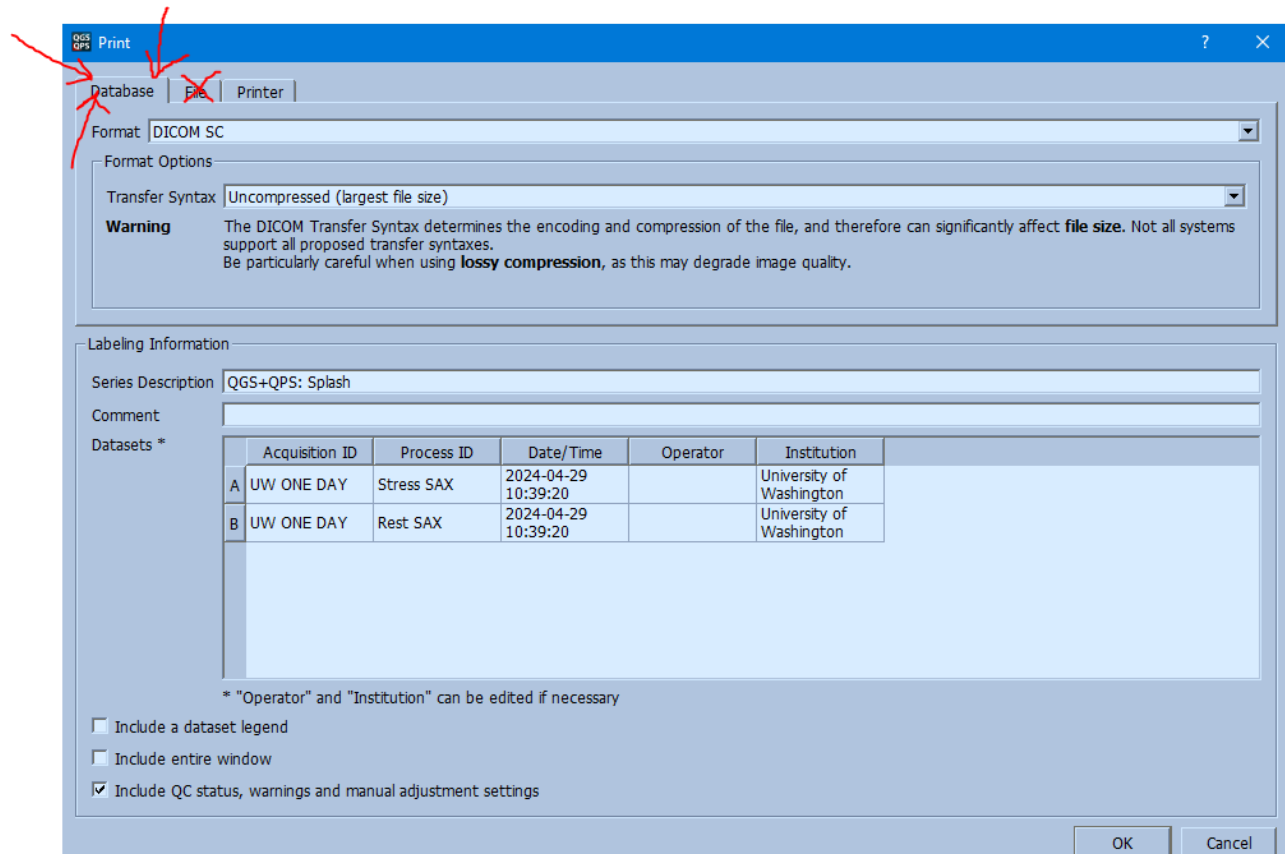
c) After you completely close out of the study, you will see this under the patient's name in Cedars

| QGS+QPS: Splash | (3) x 1920x1113 | 2023-10-12 18:51:55 | Unknown Isotope | L | • | NM |

c) Click Export to send to PACS (top left hand side of the screen)

26) Open Powerscribe and enter your user ID and password. Paste your report from Cedars into the results for the patient

a) PowerScribe: received an email with username (AMC account name) and password. Login through this desktop icon.
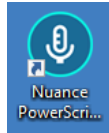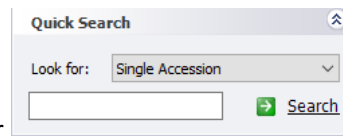
b) Search for patient by MRN or accession number

c) Copy and paste text from Cedars into PowerScribe

d) Fill out the very bottom section (the rest should be already filled out)

e) Click Insert and then Contributors to add any other residents/fellows/APPs who helped read the study or performed the stress test.

f) Once finished, hit Prelim & Approve

Troubleshooting Cedars

Problem: Can't find patient or study in CSI!

Possible solutions: Make sure that the Shared Database SHARED_DB is selected on the left in CSI, and that the time window filter includes the time of the study you are looking for.

Problem: Stress EF's are zero or not calculated!

Possible solutions: The **most common reason** for this problem is that the stress images have been incorrectly flagged as rest images. There are two ways to address this. **Method One:** in CSI right click on the Rest/Stress indicator icon for the mislabeled study and change it to stress. Reopen QGS/QPS for that patient. Check whether this fixed the problem. If not, it may be because the "RESULTS" series the tech saved included flagging that series as rest, and when you reload, the saved results setting overrides the change you just made. If the problem is not fixed, then close the QGS/QPS window and, in CSI, select all the series for that patient EXCEPT the "RESULTS" series, and reopen QGS/QPS. Check if the problem is resolved. If not, click the "Lock" toggle on the "Function" section of the reporting pane (if the erroneous value was "locked" this will unlock it and allow the newly calculated results to be filled in). **Method Two:** In the QGS/QPS window, click the "Edit" button to the right of the image series selectors. In the window which opens, find the stress series which are mislabeled as rest and select "Stress" for each of them and close the window. Check if the problem is resolved. If not, click the "Lock" toggle on the "Function" section of the reporting pane to unlock the values. The problem should then be resolved, and it is OK to relock the values.

The **second most common reason** for this problem is that "Rst" is selected in the "Gated Sequence" selector in the "Function" section of the reporting pane. This causes Cedars to think that there are only rest gated images which are to be reported on. Change the selection to "Str-Rst", and the stress wall motion polar map should appear and values should fill in for the stress EF and volumes.

Problem: I'm not on the list of possible monitoring or supervising ECG providers

Solution: The easiest way to do this is to go back to the main QGS/QPS window, make a quick note of the Referring Physician (because we will need to select them again in a minute), and click on the dropdown arrow next to Referring Physician, and select "New …". This opens a window where you can enter your first and last name and then at the bottom of the window select the checkboxes for "Monitoring" and "Supervising" (and make sure "Referring" is unchecked) and then close the window. Re-select the referring physician that you made a note of at the beginning, and then return to the Extended ➜ History/ECG section where you left off, and your name should now be on the list of choices.

Problem: Bad LV segmentation

Click "Manual" in the upper left region of the QGS/QPS window.

Adjust the yellow masking graphic by moving any of the blue squares to exclude any extracardiac activity. Then click "Process" to trigger resegmentation. If it is now correct, return the Splash page. If it still fails, then return the Manual page, adjust the yellow mask again, and select a more restrictive reprocessing by selecting the "Mask" and/or "Constrain" toggles (found next to the "Localize" toggle just above the image area). The "Localize" toggle limits the initial LV search location to the mask, the "Mask" toggle disregards all counts outside the mask, and the "Constrain" toggle locks the LV base and apex locations to the locations of the blue boxes on the ends of the line inside the yellow mask. Once you've made your selections, press Process to resegment.

Starting from short axis images, it is not possible to reorient the images within Cedars, so if the problem is an incorrect short axis orientation (rather than just an incorrect segmentation), then you will need to ask the techs to correct the short axis orientation and send new short-axis images to Cedars.