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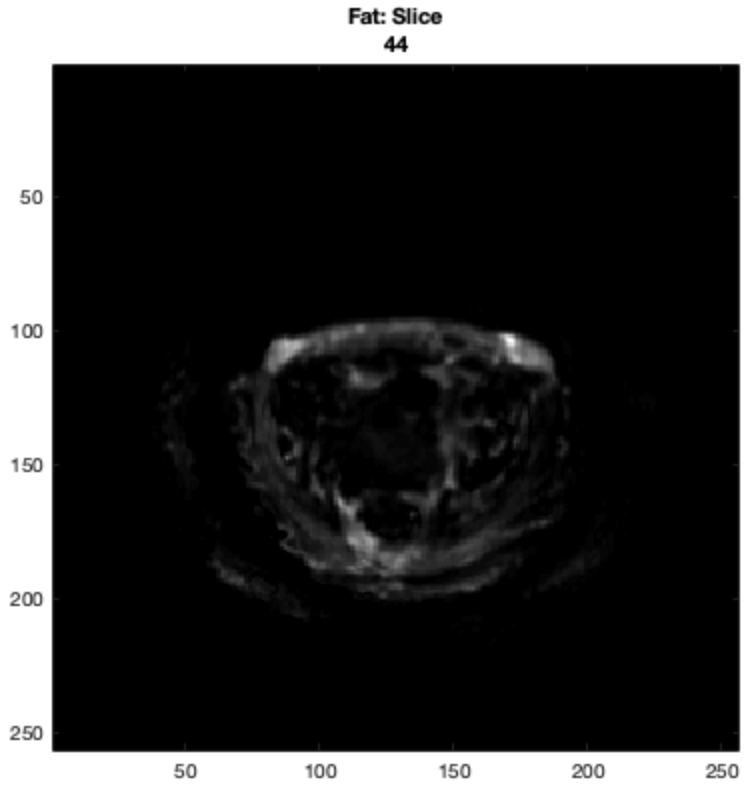
```
% Kristina Liu
% BI 265
% Measurement of Fat Lab
```

Load images

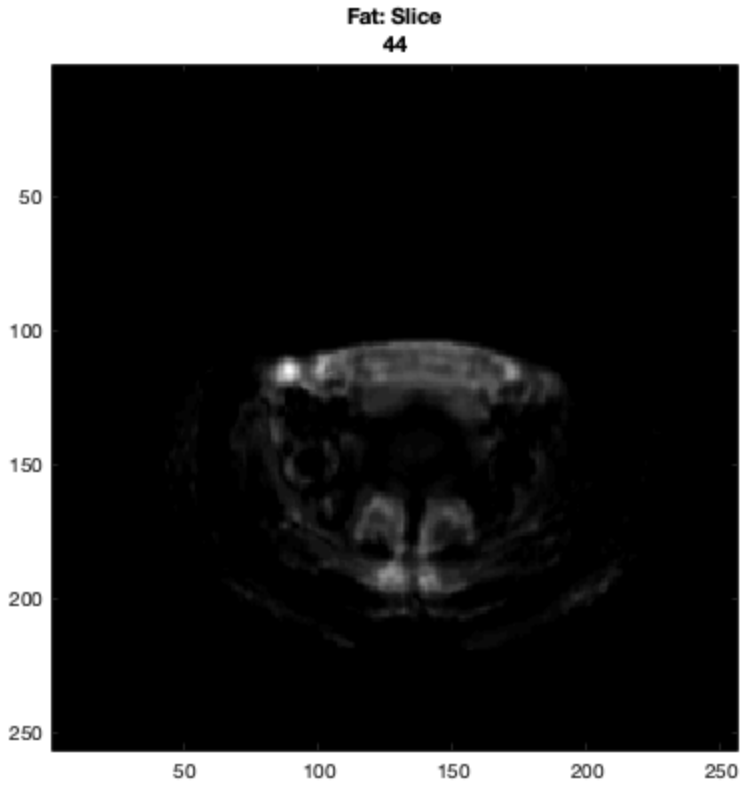
```
clear all; close all; clc

current_dir = pwd;

%input = readidf_file_pc(current_file, current_dir);
%See help for options, esp for different operating systems
%image data will be stored in <input>.img

%Pre Diet
current_file = 'data/suc047_4_S10';
VATslicePre = 30;  %15 if counting from first slice, 30 if counting
 from superior end

InPrer = read_idf_image_pc(strcat(current_file, '_In'), current_dir,
 0);
OutPrer = read_idf_image_pc(strcat(current_file, '_Out'), current_dir,
 0);
FPrer = read_idf_image_pc(strcat(current_file, '_F'), current_dir, 0);
WPrer = read_idf_image_pc(strcat(current_file, '_W'), current_dir, 0);
%record image size parameters
img_size = size(InPrer.img(:,:,:));
%FYI
%img_rl = img_size(1);
%img_ap = img_size(2);
num_slices = img_size(3);
%other methods of collecting information: im.data, im.img
```

```
%Rotate and Flip the images to be in matlab-style format
for j=1:num_slices
    FPre(:,:,j) = flipud(imrotate(FPrer.img(:,:,j),90));
    WPre(:,:,j) = flipud(imrotate(WPrer.img(:,:,j),90));
    InPre(:,:,j) = flipud(imrotate(InPrer.img(:,:,j),90));
    OutPre(:,:,j) = flipud(imrotate(OutPrer.img(:,:,j),90));
end


%Display the image by slice - check read correctly
figure('Name', strcat('Original Image: ', current_file))
for j=1:img_size(3)
    imagesc(FPre(:,:,j))
    axis image
    title({'Fat: Slice',j});
    colormap gray
    pause(0.1)
end
```



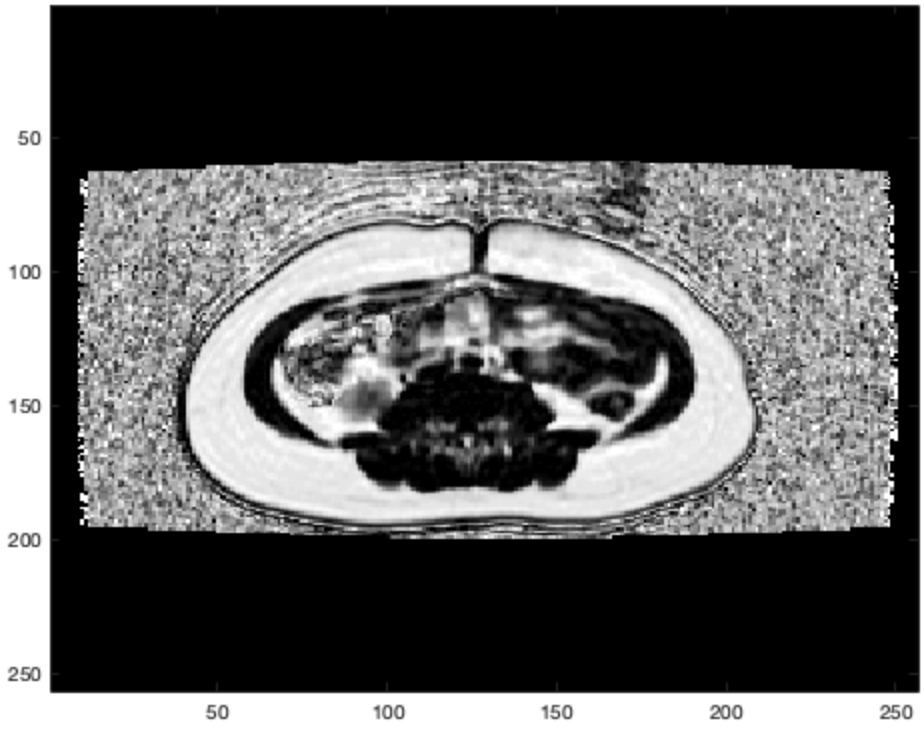

```
%Post Diet
current_dir = pwd;
current_file = 'data/suc047_2_S21';
VATslicePost = 27;   %18 if counting from first slice (inferior), 27
 if counting
%from superior end
```

```
InPostr = read_idf_image_pc(strcat(current_file, '_In'), current_dir,
 0);
OutPostr = read_idf_image_pc(strcat(current_file, '_Out'),
 current_dir, 0);
FPostr = read_idf_image_pc(strcat(current_file, '_F'), current_dir,
 0);
WPostr = read_idf_image_pc(strcat(current_file, '_W'), current_dir,
 0);

%record image size parameters
img_size = size(InPostr.img(:,:,:));
%FYI
%img_rl = img_size(1);
%img_ap = img_size(2);
num_slices = img_size(3);
%other methods of collecting information: im.data, im.img

%Rotate and Flip the images to be in matlab-style format
for j=1:num_slices
    FPost(:,:,j) = flipud(imrotate(FPostr.img(:,:,j),90));
    WPost(:,:,j) = flipud(imrotate(WPostr.img(:,:,j),90));
    InPost(:,:,j) = flipud(imrotate(InPostr.img(:,:,j),90));
    OutPost(:,:,j) = flipud(imrotate(OutPostr.img(:,:,j),90));
end


%Display the image by slice - check read correctly
figure('Name', strcat('Original Image: ', current_file))
for j=1:img_size(3)
    imagesc(FPost(:,:,j))
    axis image
    title({'Fat: Slice',j});
    colormap gray
    pause(0.1)
end
```



Calculate Fat Fraction Map in [%]

```
close all;
FF_Pre=FPre(:,:,VATslicePre)./
(FPre(:,:,VATslicePre)+WPre(:,:,VATslicePre));
figure('Name', 'Fat Fraction Pre Diet')
imagesc(FF_Pre); colormap gray

FF_Post=FPost(:,:,VATslicePost)./(FPost(:,:,VATslicePost)+ ...
    WPost(:,:,VATslicePost));
figure('Name', 'Fat Fraction Post Diet')
imagesc(FF_Post); colormap gray
```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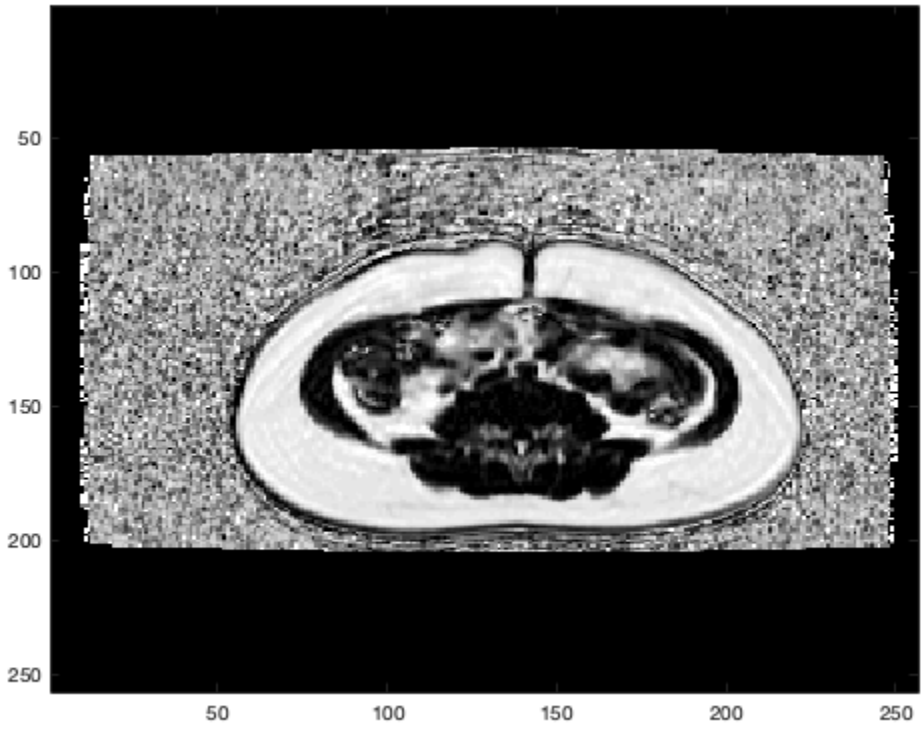
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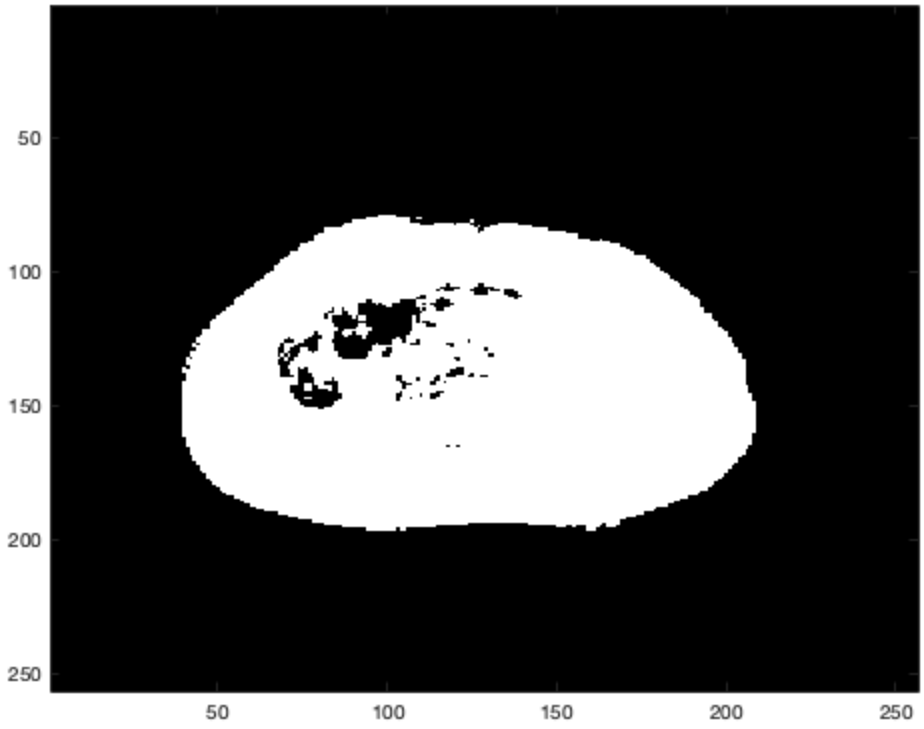
Create Body/Good SNR Mask

```
close all;
MaskInPre=zeros(img_size(1));
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if InPre(i,j,30)>125
            MaskInPre(i,j)=1;
        else
            MaskInPre(i,j)=0;
        end
    end
end
figure('Name', 'Body Mask Pre Diet')
imagesc(MaskInPre); colormap gray

MaskInPost=zeros(img_size(1));
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if InPost(i,j,30)>175
            MaskInPost(i,j)=1;
        else
            MaskInPost(i,j)=0;
        end
    end
end
figure('Name', 'Body Mask Post Diet')
imagesc(MaskInPre); colormap gray

%Threshold an image set
%example:
%Inmask = In>100;
```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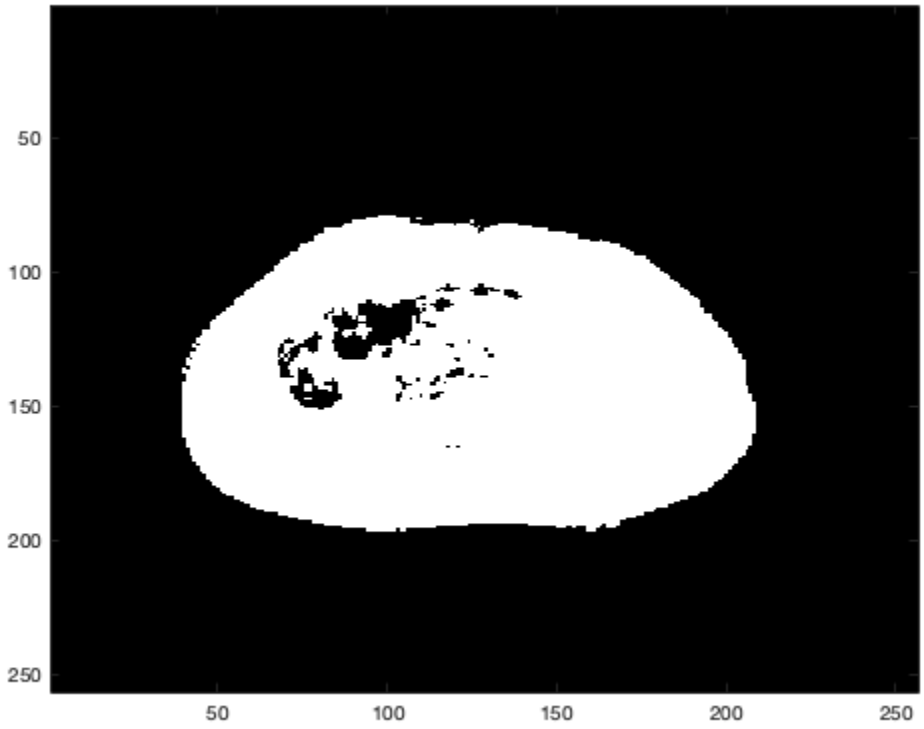
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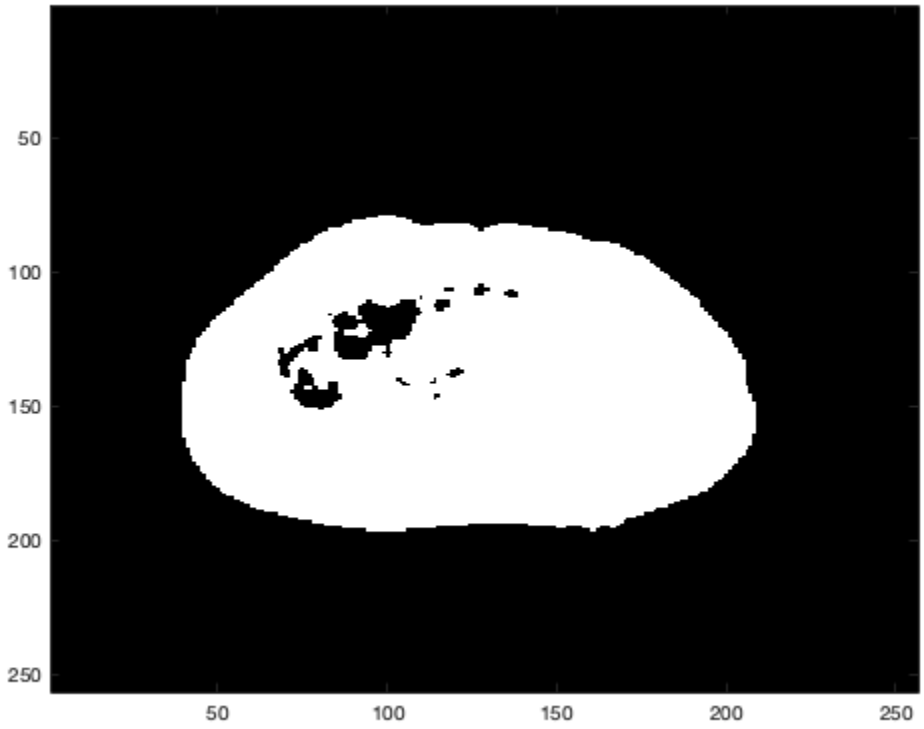
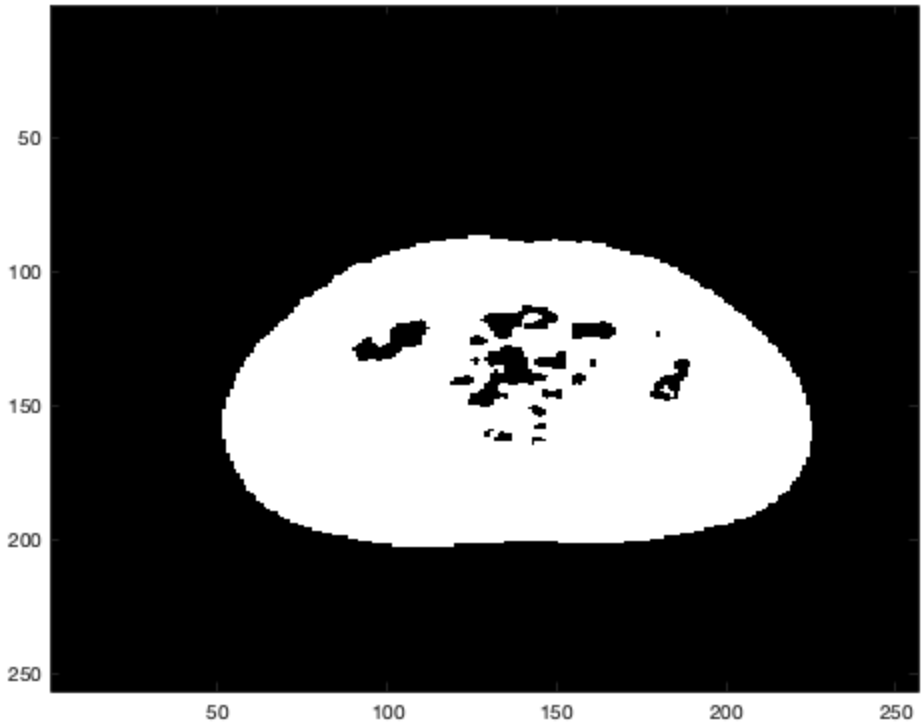
Apply a 2D filter to the mask (see help medfilt2)

```
close all;
MaskIn_Pre=medfilt2(MaskInPre);
%Evaluate filter -> Display, confirm threshold and filter choice
figure('Name', '2D Mask for Pre Diet')
imagesc(MaskIn_Pre); colormap gray
MaskIn_Post=medfilt2(MaskInPost);
%Evaluate filter -> Display, confirm threshold and filter choice
figure('Name', '2D Mask for Post Diet')
imagesc(MaskIn_Post); colormap gray
```



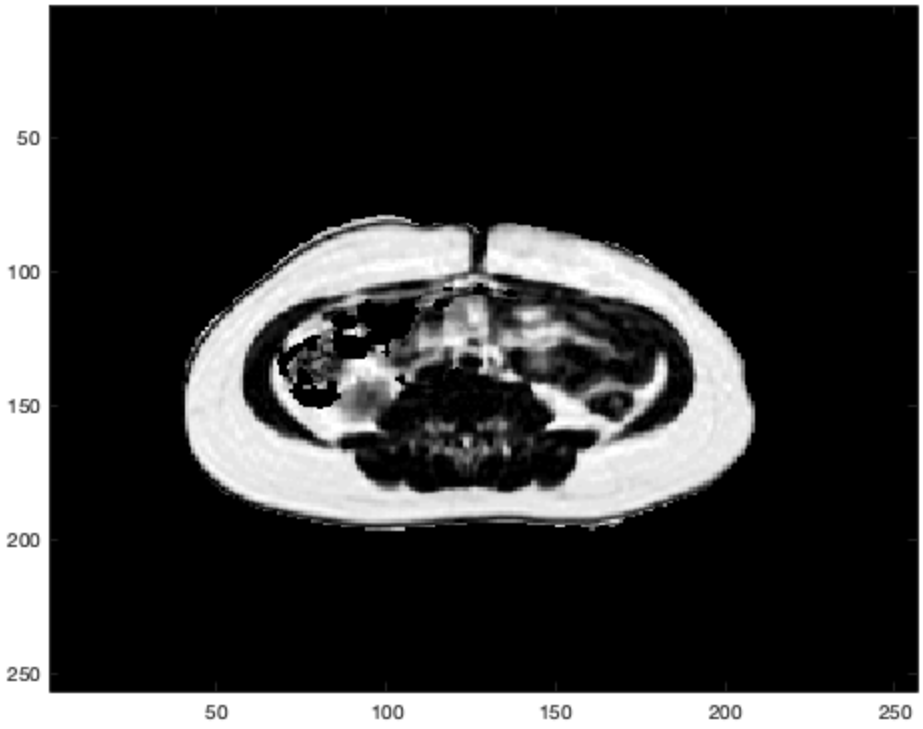


Apply this Body/SNR Mask to the FF map

```
close all;
FF_Pre_masked = MaskIn_Pre.*FF_Pre;
figure('Name', 'Pre Diet Masked FF')
imagesc(FF_Pre_masked); colormap gray

FF_Post_masked = MaskIn_Post.*FF_Post;
figure('Name', 'Post Diet Masked FF')
imagesc(FF_Post_masked); colormap gray

%Select Slice of Interest
%example:
%FFi=FF(:,:,VATslice);
```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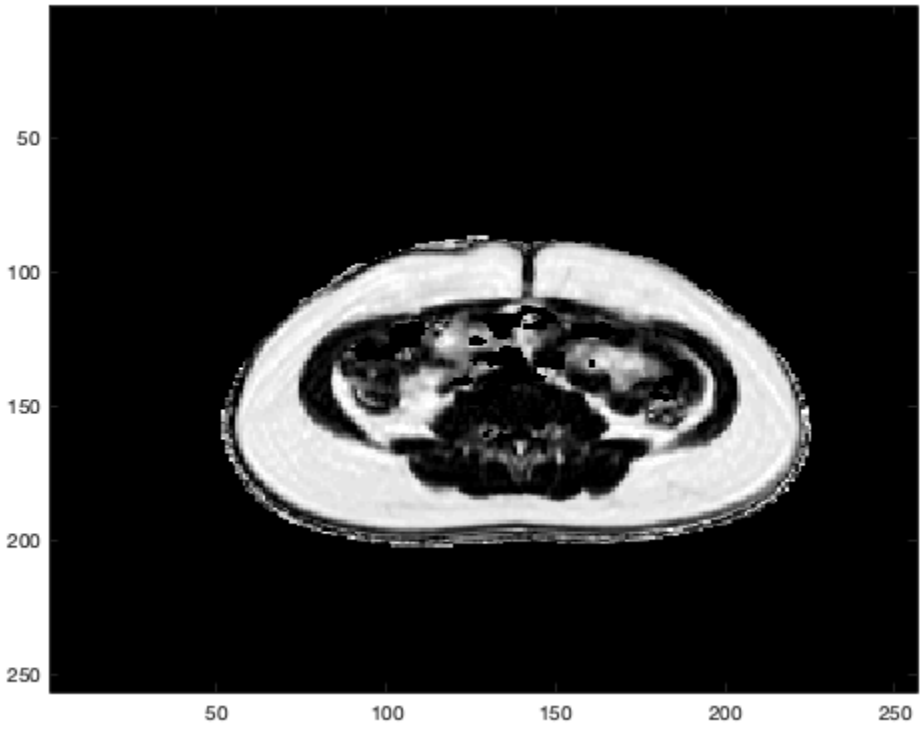
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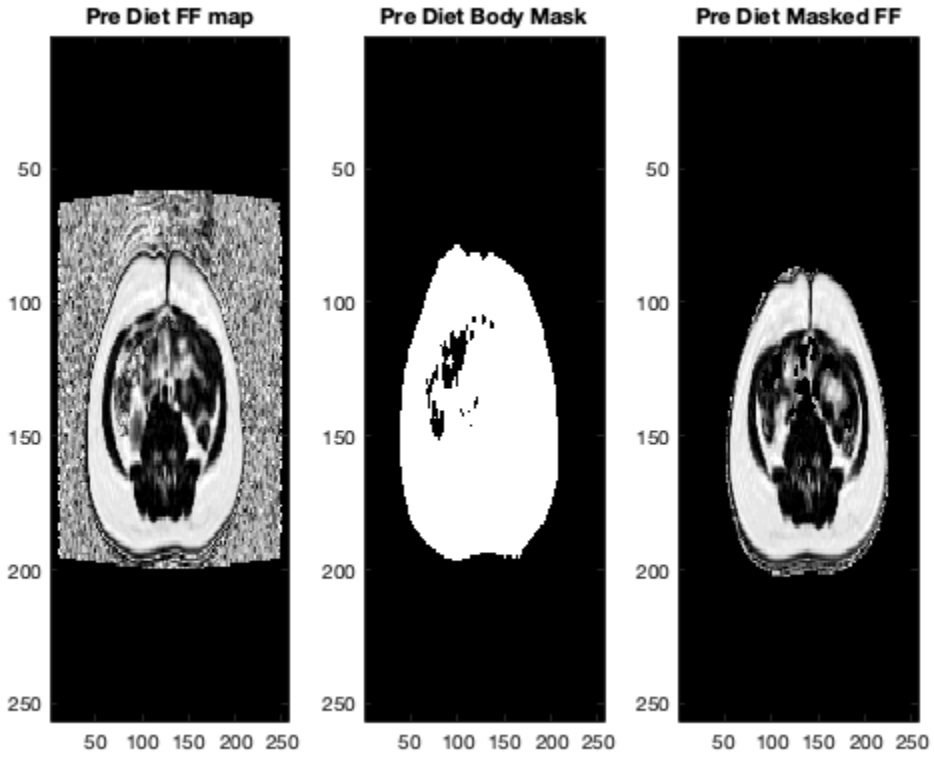
```
close all;
subplot(1,3,1)
imagesc(FF_Pre); colormap gray
title('Pre Diet FF map')
subplot(1,3,2)
imagesc(MaskIn_Pre); colormap gray
title('Pre Diet Body Mask')
subplot(1,3,3)
imagesc(FF_Post_masked); colormap gray
title('Pre Diet Masked FF')

% The FF mask has the noise outside the body which the body mask
 removed in
% the masked FF. Step 3 and 4 created a median smoothed mask that
 allowed
% values for values within the body and made everything outside 0.
% Changing the threshold will change the size and shape of the body
 mask.
% You will not want to do these steps when thresholding does not
% differetiate noise from stucture well.
```

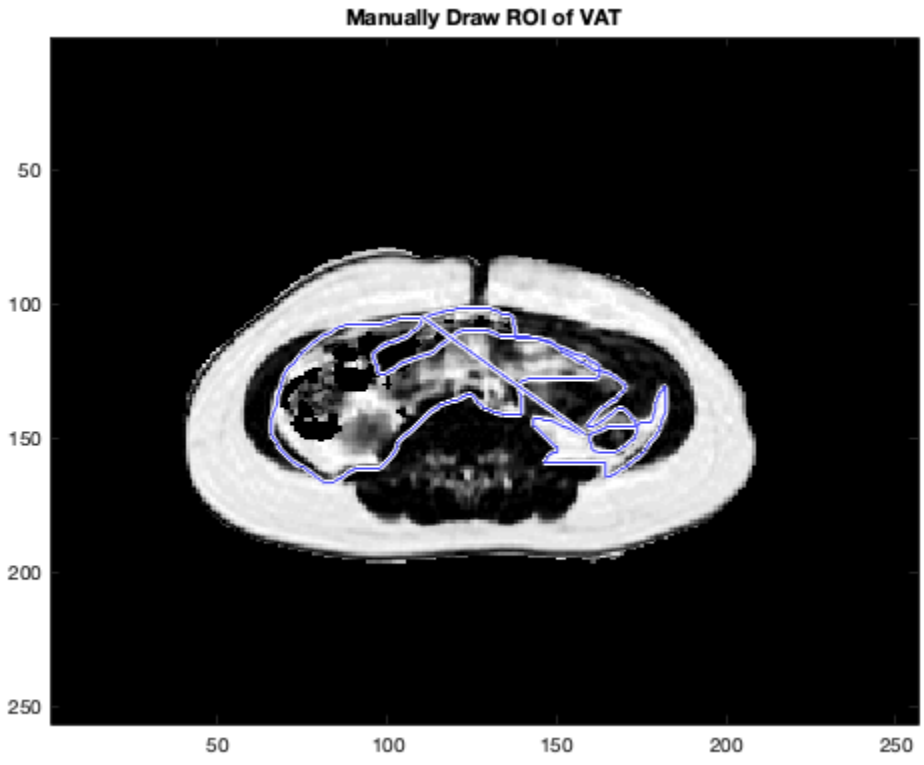


Manually Draw Visceral Fat ROI

```
close all;
%Display image
figure('name','FF Pre Diet')
```

```
imagesc(FF_Pre_masked);
title('Manually Draw ROI of VAT');
colormap gray
%start timing
tic
%Code to draw an ROI
freehandroi_man=imfreehand(gca);
manVATmask_Pre=createMask(freehandroi_man);
%end timing
manualVATtime_Pre = toc
manVATmask_Pre_num = double(manVATmask_Pre);
manVATFF_Pre=manVATmask_Pre_num.*FF_Pre_masked;
```

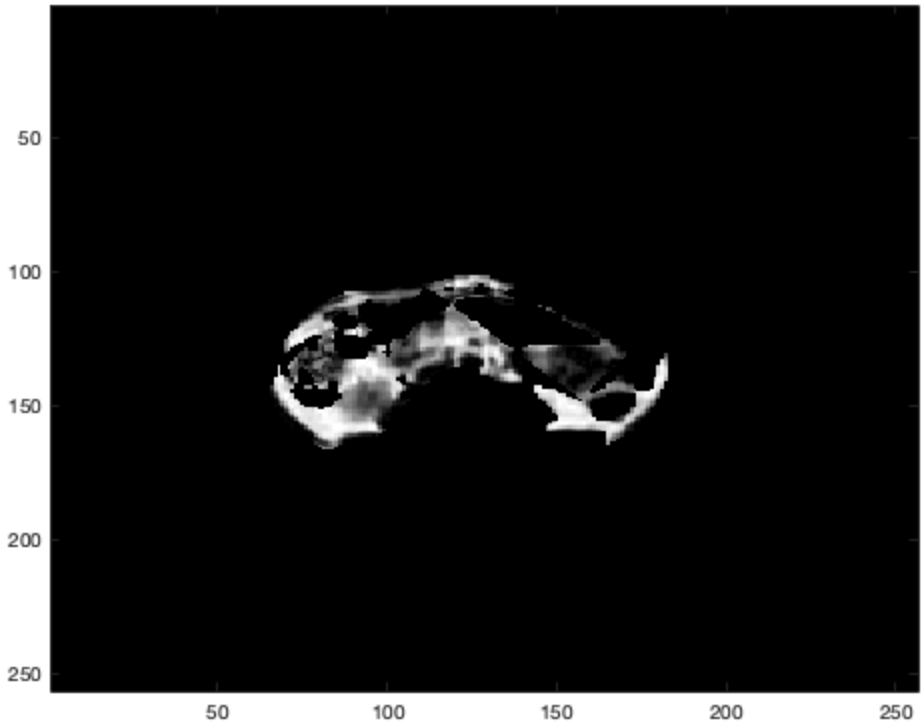
```
manualVATtime_Pre =

   29.0462
```

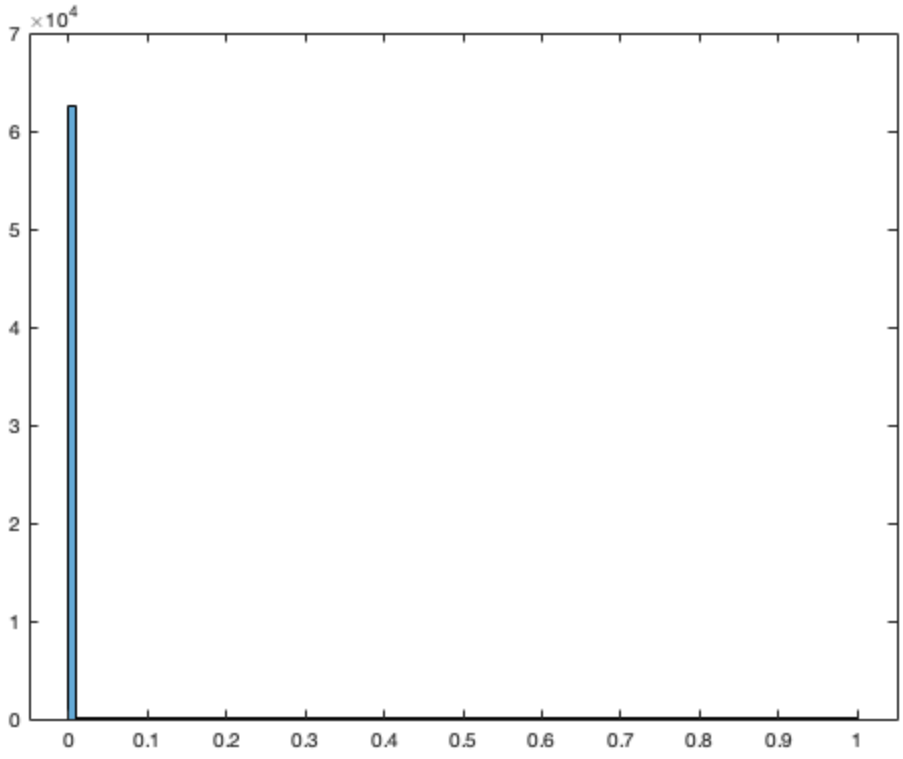


Characterize VAT ROI - histogram, size in pixels, mean, median, std

```
figure('Name', 'ROI FF Pre Diet')
imagesc(manVATFF_Pre); colormap gray
```

```
manVATFF_Pre(isnan(manVATFF_Pre))=0;
manVATFF_Pre_mean = mean(mean(manVATFF_Pre));
manVATFF_Pre_median = median(median(manVATFF_Pre));
manVATFF_Pre_std = std(std(manVATFF_Pre));
figure()
manVAT_Pre_histogram = histogram(manVATFF_Pre);
manVATFF_Pre_size = 0;
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if manVATFF_Pre(i,j)>0
            manVATFF_Pre_size = manVATFF_Pre_size+1;
        end
    end
end
%eg:
%manVATmean = mean(FFi(manVATmask)),
```



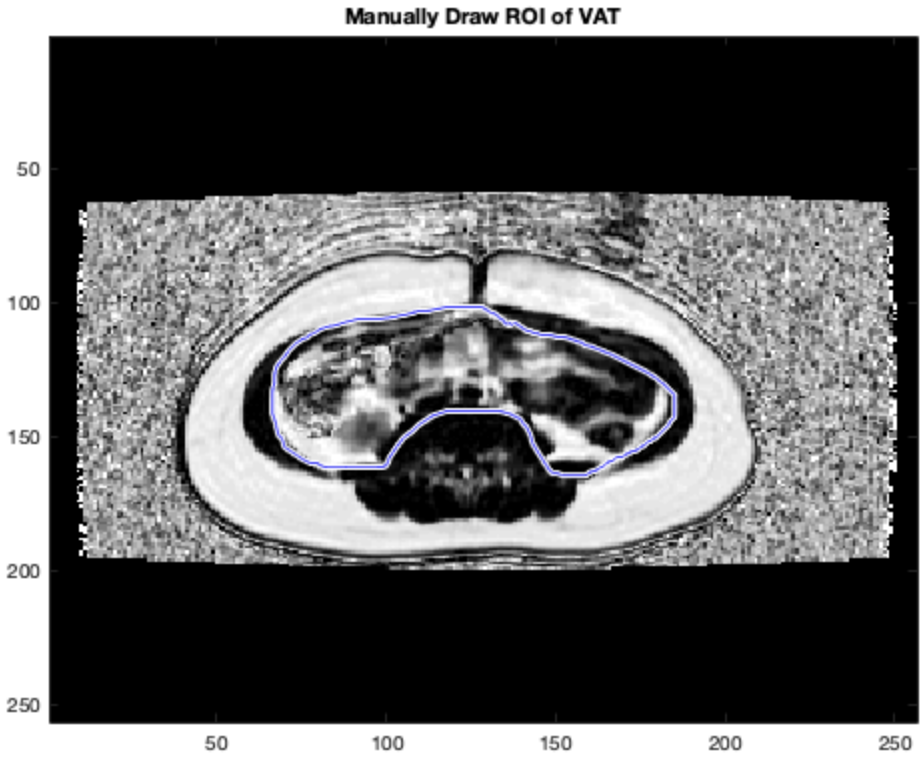


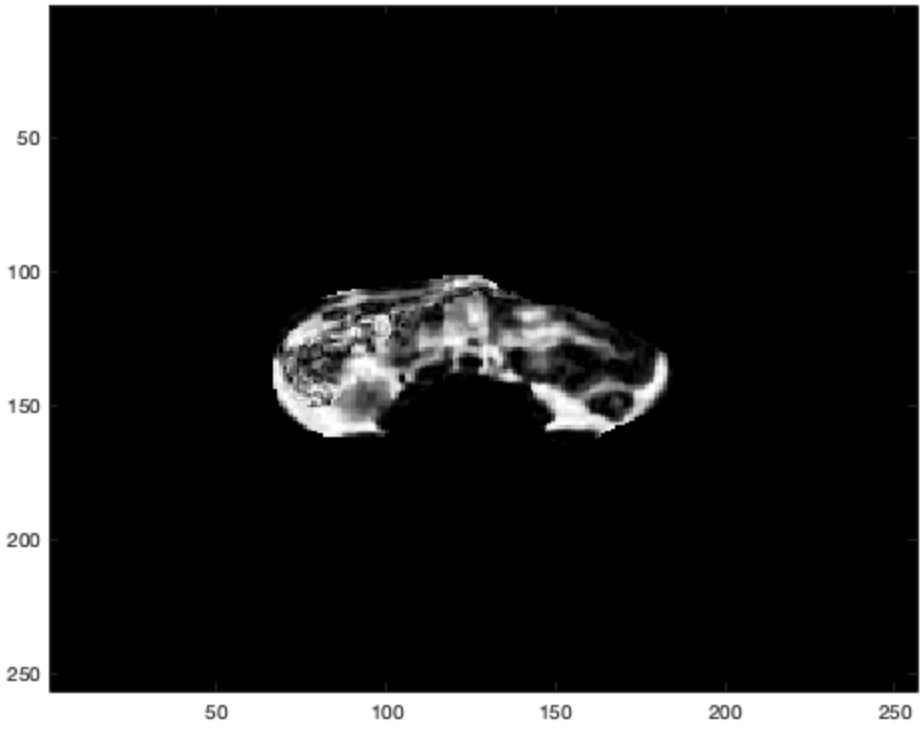
Part III - Semiautomatically Generate VAT ROI -

2-Automatically generate VAT mask and VAT-FF for: 1-Use Fat Fraction Map, 2 - Use masked Fat Fraction Map

```
close all;
%1-Manually Draw Visceral ROI
%Display image
figure('name','FF Pre Diet')
imagesc(FF_Pre);
title('Manually Draw ROI of VAT');
colormap gray
%start timing
tic
%Code to draw an ROI
freehandroi_aut=imfreehand(gca);
autVATmask_Pre=createMask(freehandroi_aut);
%end timing
autVATmask_Pre_num = double(autVATmask_Pre);
autVATroi_Pre=autVATmask_Pre_num.*FF_Pre;
figure('Name', 'Automatic ROI FF Pre Diet')
imagesc(autVATroi_Pre); colormap gray
%Threshold the FF map to > 50
autVATthresh_Pre=zeros(img_size(1));
for i = 1:img_size(1);
    for j = 1:img_size(2);
```

```
        if FF_Pre(i,j)>0.5
            autVATthresh_Pre(i,j)=autVATroi_Pre(i,j);
        else
           autVATthresh_Pre(i,j)=0;
        end
    end
end
figure('Name', 'Automatic FF Pre Diet')
imagesc(autVATthresh_Pre); colormap gray
```

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100
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200
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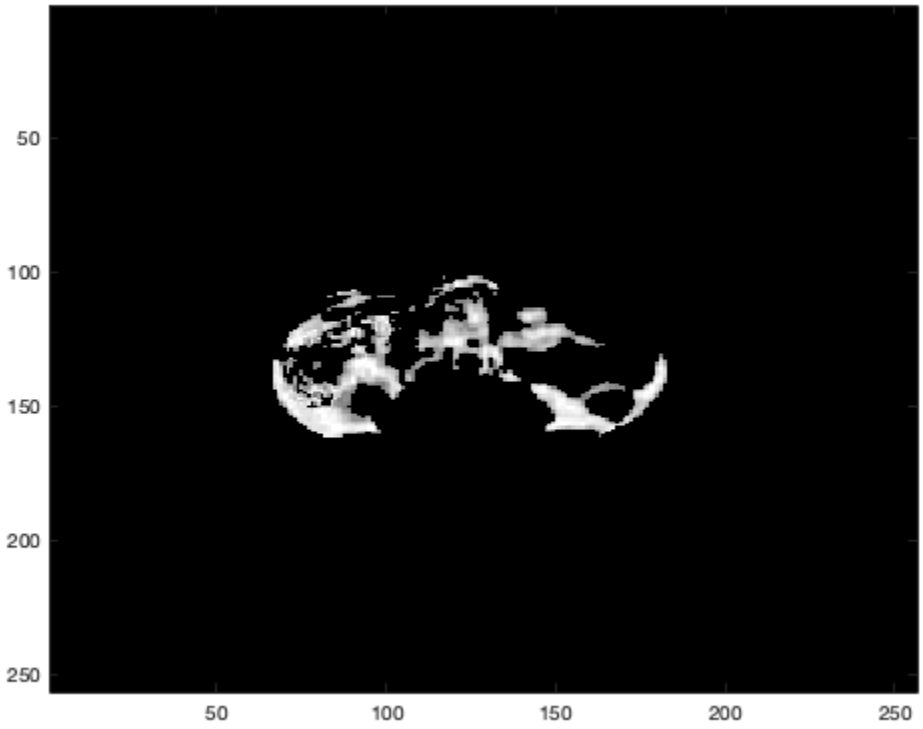
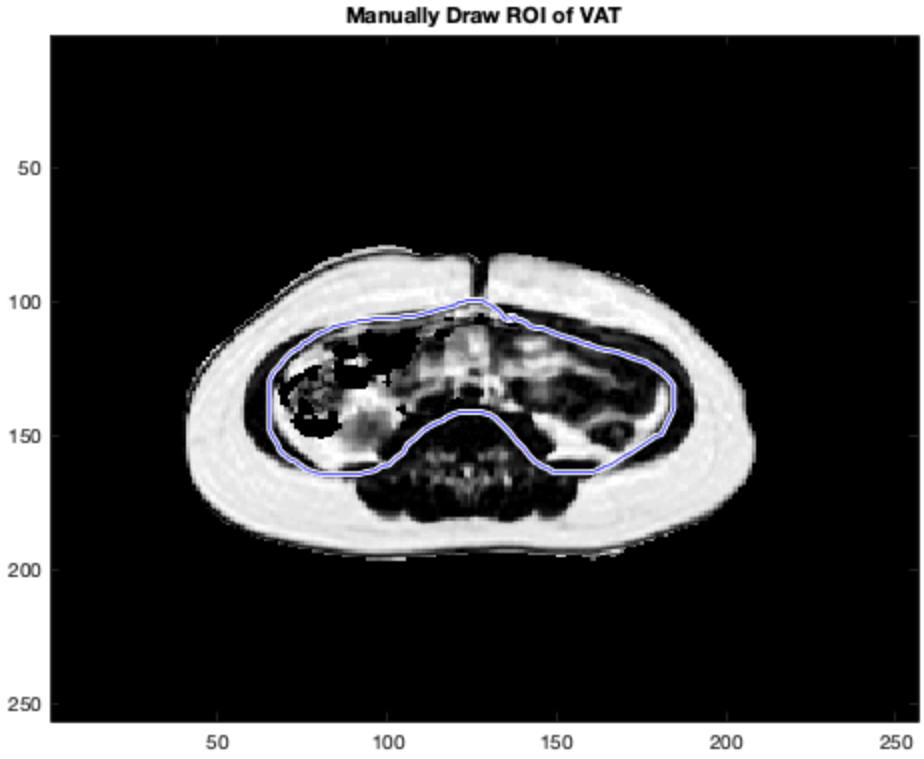
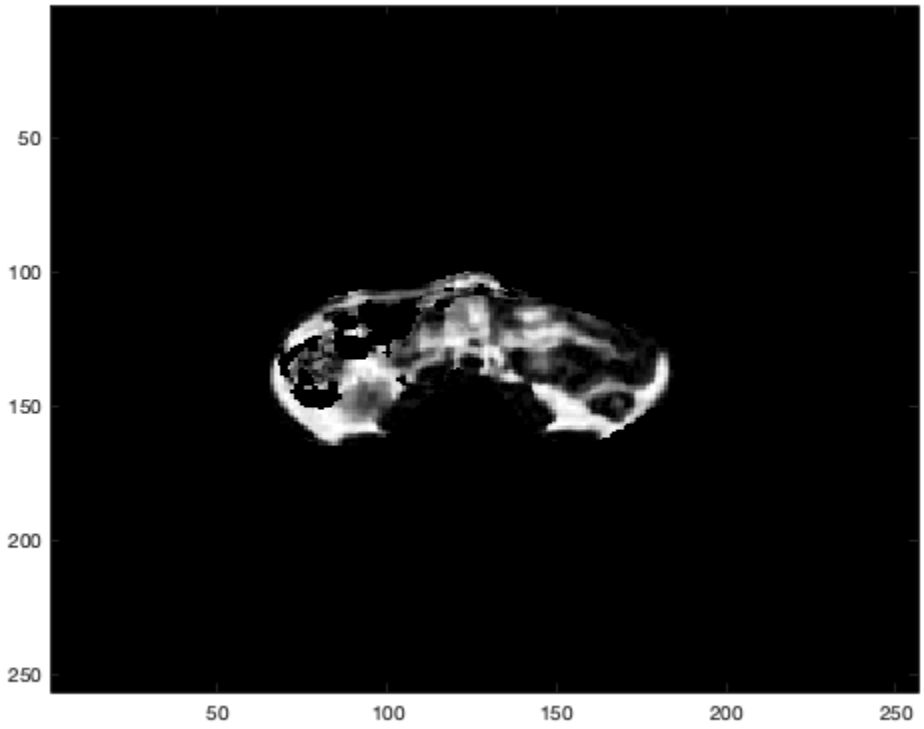

50
100
150
200
250
50
100
150
200
250

--Repeat for the masked Fat Fraction Map

```
close all;
%1-Manually Draw Visceral ROI
%Display image
figure('name','FF Pre Diet')
imagesc(FF_Pre_masked);
title('Manually Draw ROI of VAT');
colormap gray
%start timing
tic
%Code to draw an ROI
freehandroi_aut_masked=imfreehand(gca);
autVATmask_Pre_masked=createMask(freehandroi_aut_masked);
%end timing
autVATmask_Pre_num_masked = double(autVATmask_Pre_masked);
autVATroi_Pre_masked=autVATmask_Pre_num_masked.*FF_Pre_masked;
figure('Name', 'Automatic ROI FF Pre Diet')
imagesc(autVATroi_Pre_masked); colormap gray
%Threshold the FF map to > 50
autVATthresh_Pre_masked=zeros(img_size(1));
%Generate a VAT ROI Fat Fraction (masked by viscera and by FF > 50)
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if FF_Pre_masked(i,j)>0.5
            autVATthresh_Pre_masked(i,j)=autVATroi_Pre_masked(i,j);
        else
           autVATthresh_Pre_masked(i,j)=0;
        end
    end
end

%Make a Figure of VAT ROI FF image
figure('Name', 'Automatic masked FF Pre Diet')
imagesc(autVATthresh_Pre_masked); colormap gray
```


Manually Draw ROI of VAT
50
100
150
200
250
50
100
150
200
250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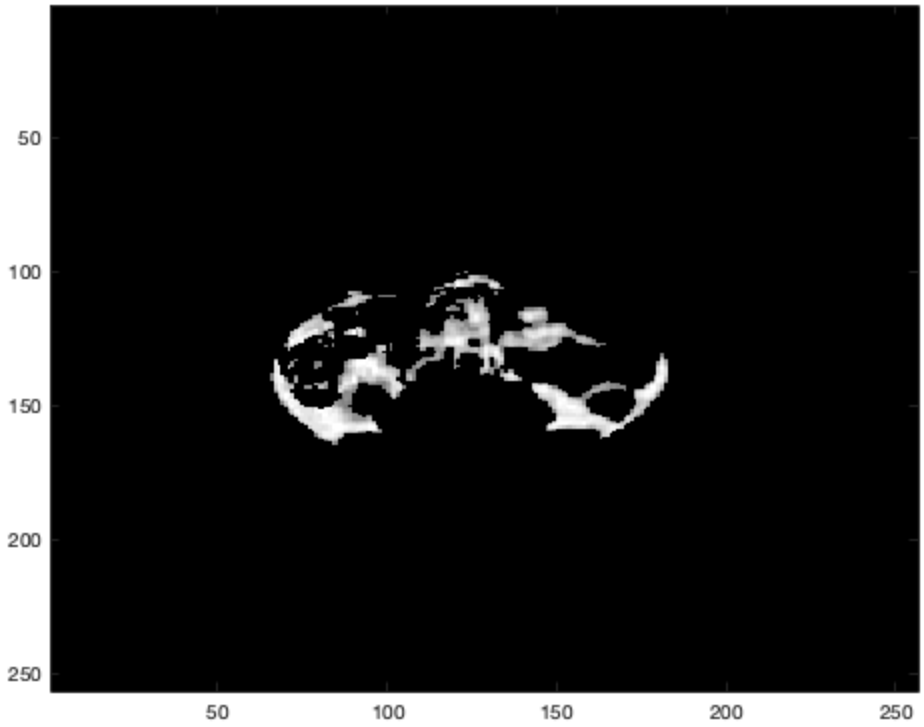
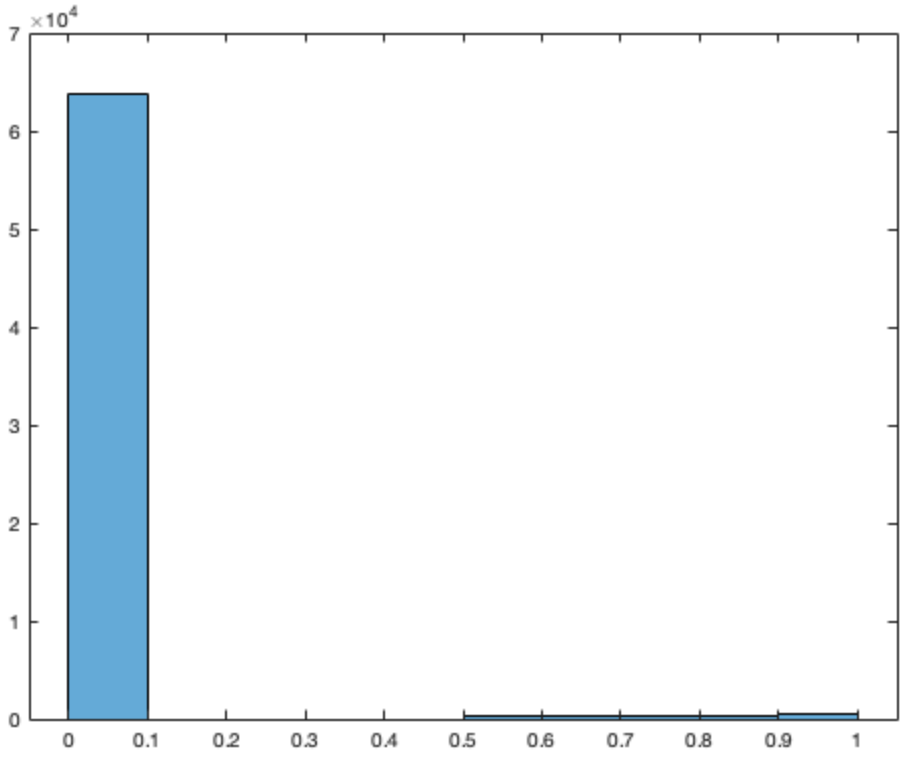
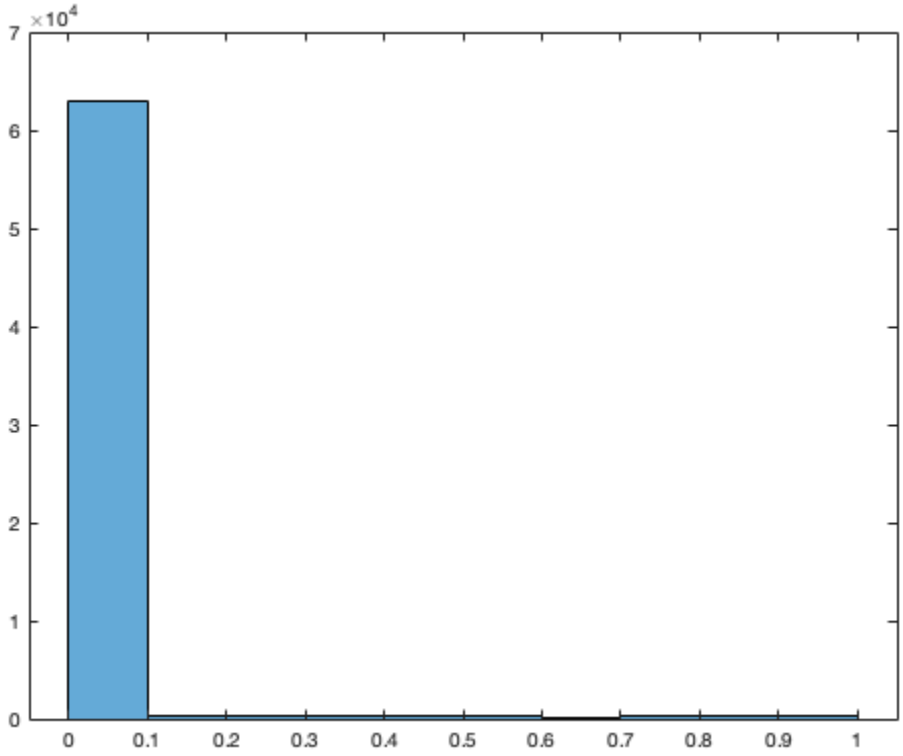



```
close all;
%Create a histogram of the VAT ROI Fat Fraction values
figure('Name', 'Visceral FF ROI')
autVAT_Pre__mask_histogram = histogram(autVATthresh_Pre_masked,10);
figure('Name', 'VAT FF ROI')
manVAT_Pre_histogram = histogram(manVATFF_Pre,10);
% Both histograms contain a majority of 0s.
% The visceral FF ROI has distribution from
% 0.1 to 1. VAT ROI has a distribution between 0.5 and 1.
% We have this shape for VAT because we
% thresholded all values below 0.5 while for the visceral ROI we
 manually
% drew it out.
```


×10^4
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

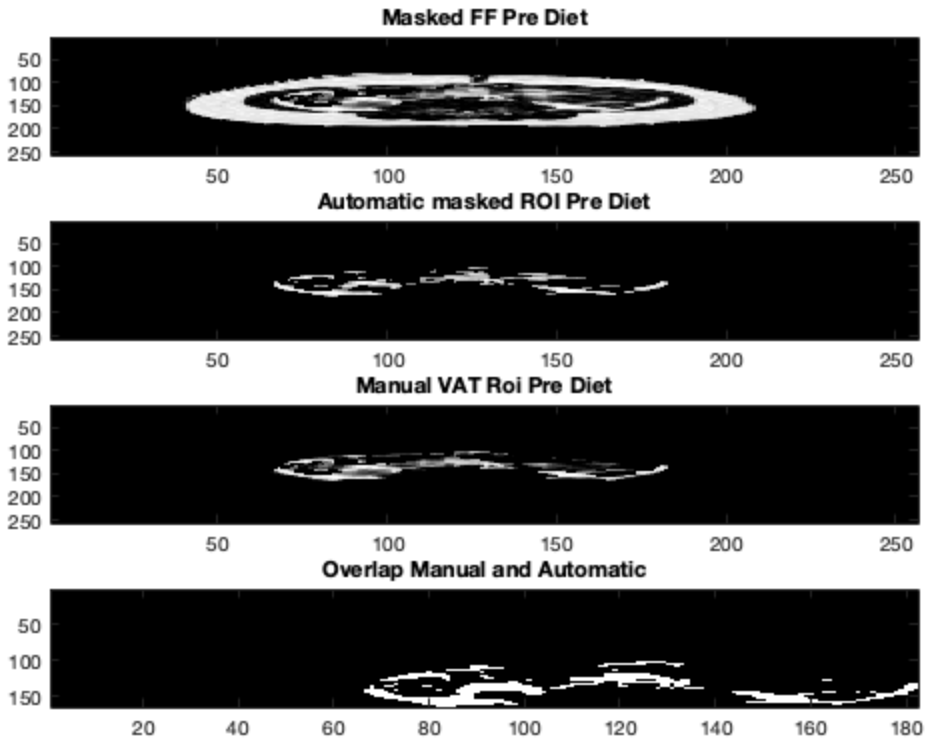

×10^4
7
6
5
4
3
2
1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

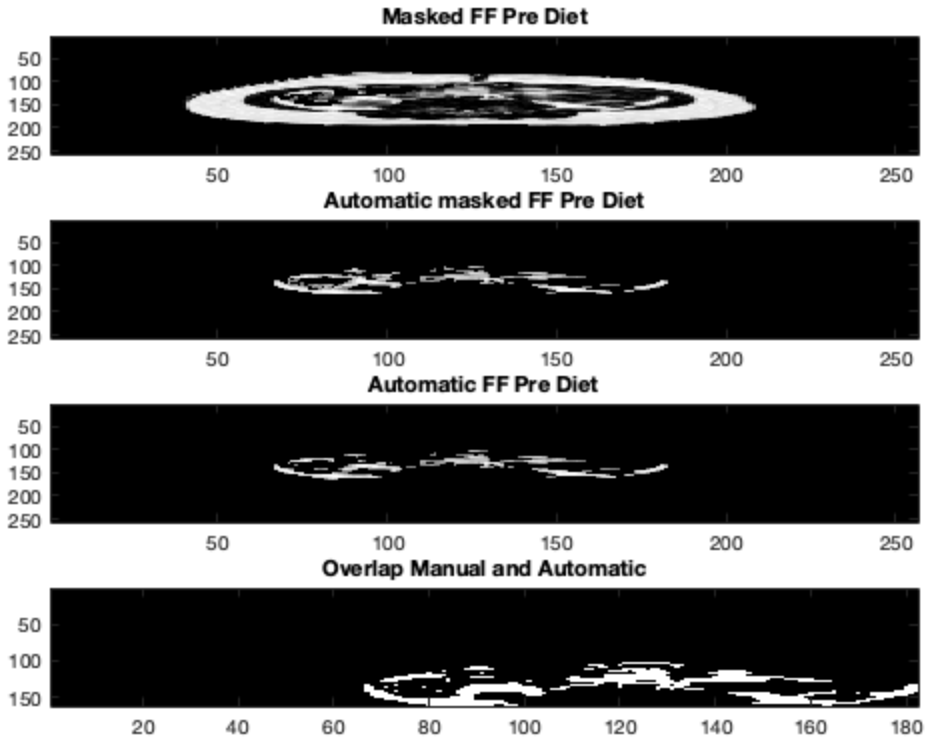
Part IV - Determine Accuracy, Differences

```
close all;
autVATthresh_Pre(isnan(autVATthresh_Pre))=0;
autVATthresh_Pre_mean = mean(mean(autVATthresh_Pre));
autVATthresh_Pre_median = median(median(autVATthresh_Pre));
autVATthresh_Pre_std = std(std(autVATthresh_Pre));
autVATthresh_Pre_size = 0;
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Pre(i,j)>0
            autVATthresh_Pre_size = autVATthresh_Pre_size+1;
        end
    end
end
autVATthresh_Pre_masked(isnan(autVATthresh_Pre_masked))=0;
autVATthresh_Pre_masked_mean = mean(mean(autVATthresh_Pre_masked));
autVATthresh_Pre_masked_median =
 median(median(autVATthresh_Pre_masked));
autVATthresh_Pre_masked_std = std(std(autVATthresh_Pre_masked));
autVATthresh_Pre_masked_size = 0;
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Pre(i,j)>0
            autVATthresh_Pre_masked_size =
 autVATthresh_Pre_masked_size+1;
        end
    end
end

overlap_masked_FF_man_ROI = zeros(size(img_size));
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Pre_masked(i,j) && manVATFF_Pre(i,j)>0
            overlap_masked_FF_man_ROI(i,j) = 1;
        end
    end
end

overlap_VAT_Visc = zeros(size(img_size));
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Pre_masked(i,j) && manVATFF_Pre(i,j)>0
            overlap_VAT_Visc = overlap_VAT_Visc+1;
        end
    end
end
overlap_both_auto = zeros(size(img_size));
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Pre_masked(i,j) && autVATthresh_Pre(i,j)>0
            overlap_both_auto(i,j) = 1;
        end
```

```
    end
end

overlap_mask = zeros(size(img_size));
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Pre_masked(i,j) && autVATthresh_Pre(i,j)>0
            overlap_mask = overlap_mask+1;
        end
    end
end
%Calculate Dice Coefficient & the %Difference in Size
%A - Compare VAT ROI on masked FF vs. manual VAT ROI
DC_VAT_Visc= 2.*overlap_both_auto/(manVATFF_Pre_size + ...
    autVATthresh_Pre_masked_size);
VAT_Visc_perc_diff = (manVATFF_Pre_size-
autVATthresh_Pre_masked_size)/...
    manVATFF_Pre_size;

%B - Compare VAT ROI on masked FF to the VAT ROI on FF (not masked)

DC_VAT_Visc= 2.*overlap_mask/(autVATthresh_Pre_size + ...
    autVATthresh_Pre_masked_size);
mask_perc_diff = (autVATthresh_Pre_size +
 autVATthresh_Pre_masked_size)/...
    autVATthresh_Pre_size;

%Display FF image, 2 masks, and overlap of the 2 masks
% A
close all;
figure('Name', 'A')
subplot(4,1,1)
imagesc(FF_Pre_masked); colormap gray
title('Masked FF Pre Diet')
subplot(4,1,2)
imagesc(autVATthresh_Pre_masked); colormap gray
title('Automatic masked ROI Pre Diet')
subplot(4,1,3)
imagesc(manVATFF_Pre); colormap gray
title('Manual VAT Roi Pre Diet')
subplot(4,1,4)
imagesc(overlap_masked_FF_man_ROI); colormap gray
title('Overlap Manual and Automatic')
% B
figure('Name', 'B')
subplot(4,1,1)
imagesc(FF_Pre_masked); colormap gray
title('Masked FF Pre Diet')
subplot(4,1,2)
imagesc(autVATthresh_Pre); colormap gray
title('Automatic masked FF Pre Diet')
subplot(4,1,3)
imagesc(autVATthresh_Pre_masked); colormap gray
title('Automatic FF Pre Diet')
```

```
subplot(4,1,4)
imagesc(overlap_both_auto); colormap gray
title('Overlap Manual and Automatic')

% The manual approach allows for fat fractions less than 0.5 percent
%which the automatic ones does not.
% Automatically thresholding with an without noise makes no difference
% because they are NaN and replaced with zeros.
```





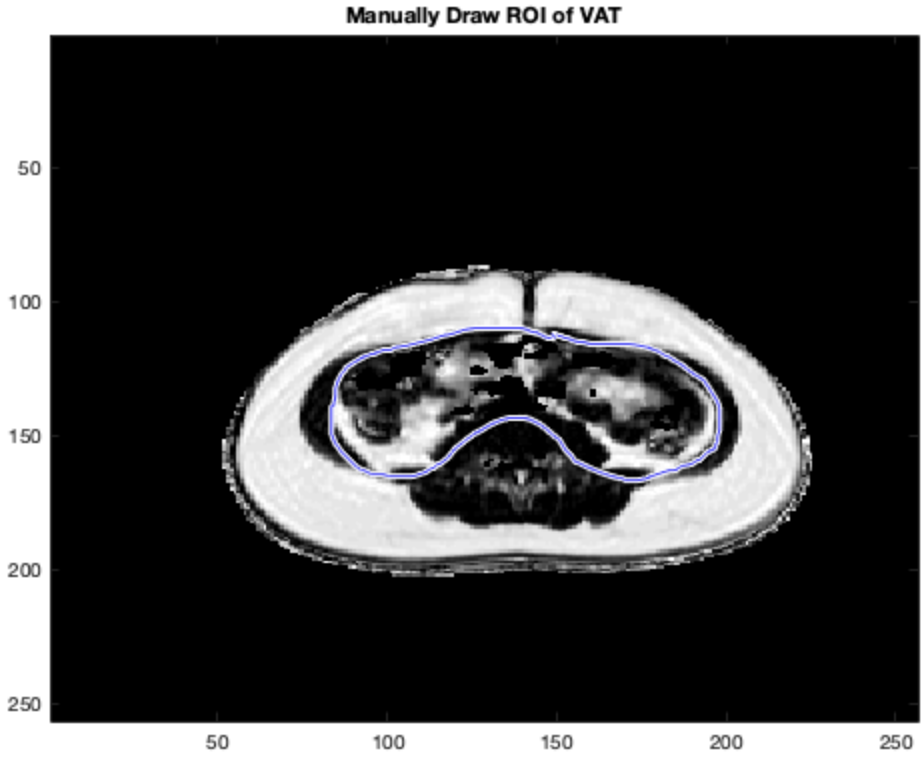

```
%Calculate & Report stats on the VAT ROIs
%Summary of Results
disp(sprintf('Parameter        Manual VAT        Semiauto VAT'))
disp(sprintf('volume             2973               1958'))
disp(sprintf('median               0                  0'))
disp(sprintf('mean               0.0243        0.0227'))
disp(sprintf('st dev             0.0.0940        0.0981'))
```

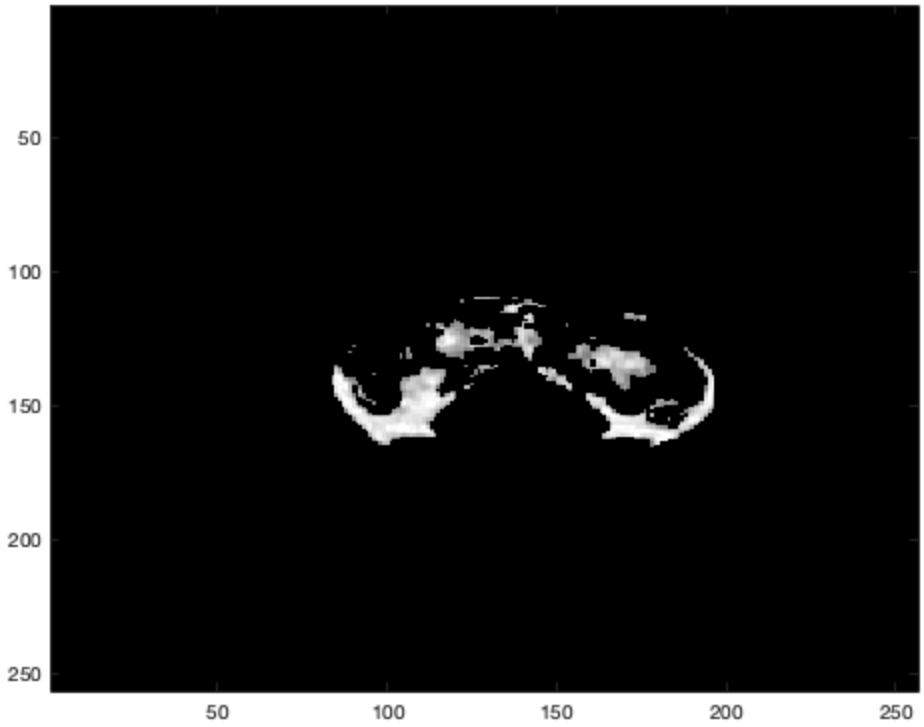
```
Parameter        Manual VAT        Semiauto VAT
volume             2973               1958
median               0                  0
mean               0.0243        0.0227
st dev             0.0.0940        0.0981
```

Part V - Compare Post VAT vs. Pre VAT

```
close all;
%1-Manually Draw Visceral ROI
%Display image
figure('name','FF Post Diet')
imagesc(FF_Post_masked);
title('Manually Draw ROI of VAT');
colormap gray
%start timing
tic
%Code to draw an ROI
```

```
freehandroi_aut_Post=imfreehand(gca);
autVATmask_Post_masked=createMask(freehandroi_aut_Post);
%end timing
autVATmask_Post_num_masked = double(autVATmask_Post_masked);
autVATroi_Post_masked=autVATmask_Post_num_masked.*FF_Post_masked;
%Threshold the FF map to > 50
autVATthresh_Post_masked=zeros(img_size(1));
%Generate a VAT ROI Fat Fraction (masked by viscera and by FF > 50)
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if FF_Post_masked(i,j)>0.5
            autVATthresh_Post_masked(i,j)=autVATroi_Post_masked(i,j);
        else
           autVATthresh_Post_masked(i,j)=0;
        end
    end
end

%Make a Figure of VAT ROI FF image
figure('Name', 'Automatic masked FF Post Diet')
imagesc(autVATthresh_Post_masked); colormap gray
```

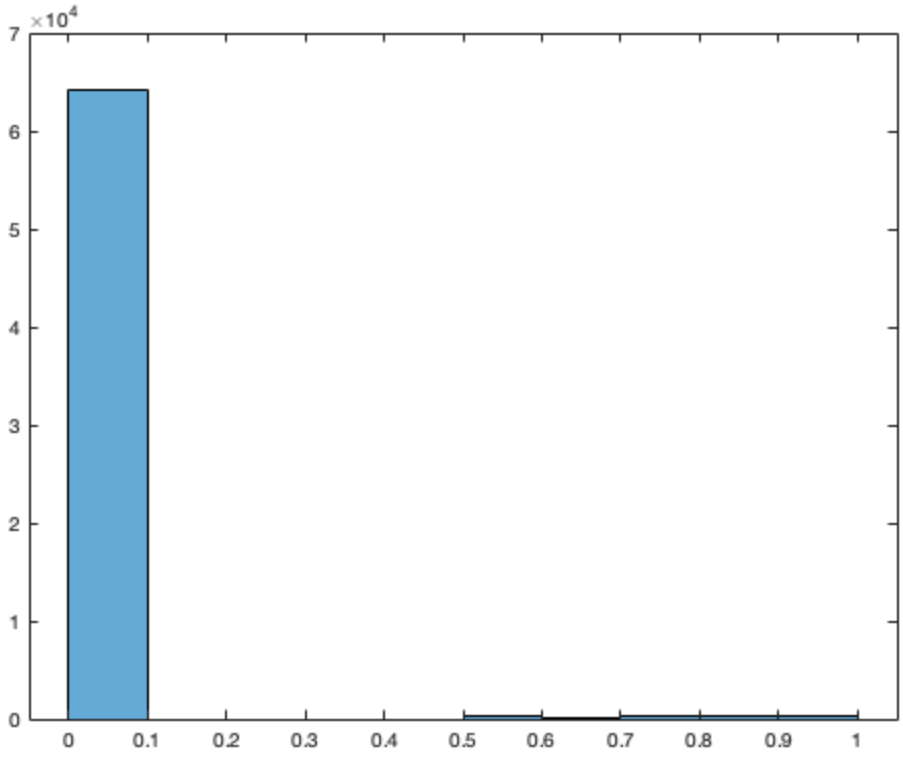


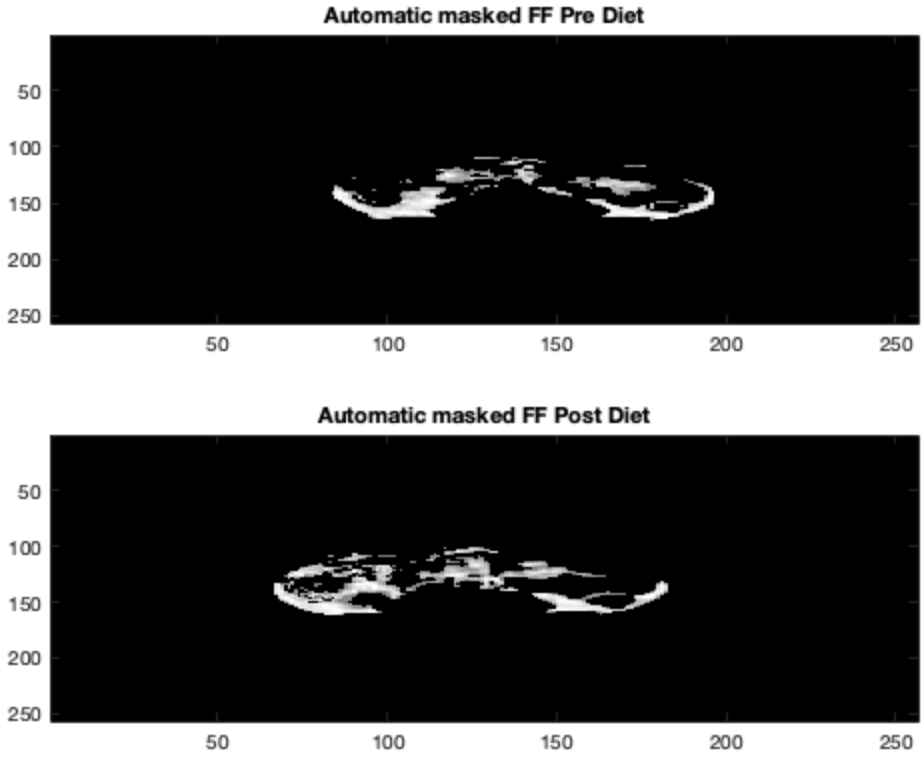



```
close all;
autVATFF_Pre(isnan(autVATthresh_Post_masked))=0;
Post_mean = mean(mean(autVATthresh_Post_masked));
Post_median = median(median(autVATthresh_Post_masked));
Post_std = std(std(autVATthresh_Post_masked));
figure()
Post_histogram = histogram(autVATthresh_Post_masked, 10);
Post_size = 0;
for i = 1:img_size(1)
    for j = 1:img_size(2)
        if autVATthresh_Post_masked(i,j)>0
            Post_size = Post_size+1;
        end
    end
end
Pre_Post_diff = (autVATthresh_Pre_size - Post_size)/
autVATthresh_Pre_size
figure()
subplot(2,1,1)
imagesc(autVATthresh_Post_masked); colormap gray
title('Automatic masked FF Pre Diet')
subplot(2,1,2)
imagesc(autVATthresh_Pre); colormap gray
title('Automatic masked FF Post Diet')
% The mean for Day10 is lower than Pre Diet, as is the standard
 deviation
```

```
% The patient had a decrease in visceral fat from the diet.
```

```
Pre_Post_diff =

    0.2975
```





Part VI SAT Measurement

Everything within the subcutaneous fat can be manually drawn out from the in phase image to make a body mask. Everything inside the mask will be a 0, leaving the subcutaneous fat. when applied to the fat fraction map created from in and out of phase images.

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