Cardiovascular Suite™

User Manual

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1. Registration

1.1. Hardware Requirements
Cardiovascular Suite UE can be installed on Apple computers.

**Minimum Requirements**
- MacBook Pro, Intel Core 2 Duo, 2GB RAM memory, 120GB Hard Disk, 1280x800 resolution, Firewire 800.
- or
- iMac, Intel Core 2 Duo, 2GB RAM memory, 120GB Hard Disk, 1280x800 resolution, Firewire 800.
- Mac OS X 10.5, QuickTime 7 or later.
- Grass Valley - Canopus ADVC55 hardware video converter (to capture analog video sources).

For the installation of video converter ADVC55, please refer to its instruction manual.

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**NOTE**
Canopus, ADVC are registered trademarks and Grass Valley is a trademark of GVBB Holdings S.a.r.l.
MacBook, Firewire, Mac OS, QuickTime are registered trademark of Apple Inc.

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1.2. Software installation
The software installation follows the usual procedure of installing software on Mac OS X. For information or support please contact Quipu.

**Installation**
- Insert the Cardiovascular Suite CD-ROM,
- or
- mount the Cardiovascular Suite CD-ROM image file (*.dmg file) on your desktop.
- Copy Cardiovascular Suite into the Application Folder.
- Eject the Cardiovascular Suite CD-ROM,
- or
- unmount the Cardiovascular Suite CD-ROM image file.
- Run Cardiovascular Suite from your Application Folder.
- Follow the given instructions to complete installation.
1.3. Registration
When you first start, Cardiovascular Suite requires registration of the product. The *Cardiovascular Suite Registration Assistant* window shows the **Activation Key** (1) to be sent to Quipu, [support@quipu.eu](mailto:support@quipu.eu) via email, to obtain the **License Key**. This code must be entered to register the software.

![Cardiovascular Suite Registration Assistant](image)

**Get your license**
- Start Cardiovascular Suite. If the software is not registered, the *Cardiovascular Suite Registration Assistant* is shown.
- Press the **Copy and Send Activation Key** button.
- The default email program will open with an email addressed to [support@quipu.eu](mailto:support@quipu.eu) and contains the activation key. Within 24 hours you will receive an email containing the license key.

![Cardiovascular Suite Registration Assistant](image)

**Enter the license key**
- Start Cardiovascular Suite. If the software is not registered, the *Cardiovascular Suite Registration Assistant* is shown.
- Press the **Enter License Key ...** button.
- In *Cardiovascular Suite Registration* window, enter the name of the person/institution that is registering the product and enter the license key. Confirm with **Register**.
2. Home Screen

To access Cardiovascular Suite you must log in with a username and password (1). You can add or edit the users through the Users button, which is the only button (2) active before the user is authenticated.

**NOTE:** The default user present at the first start is: Username = root, Password = 123456.

**Description of main controls:**
- **Users**: manages users.
- **Settings**: sets the options of the program.
- **Archive**: manages the archives.
- **New Study**: add a new study.
- **Manuals**: open to the user manual.
- **Quit**: exit the program.

**Authenticate as a user**
- Enter the username and password (1).
- If you forgot your password, press the Forgot Password? to get the password hint.
- Click Authenticate.
- The username appears in the status bar at the bottom left (3).

**Disconnect a user**
- Click the Users Manager button, located in the status bar at the bottom left (3).
- Select Disconnect.
With the *About Cardiovascular Suite* button in the home screen, top left (4), you get information about the version of the software.
3. User Management

Allows you to manage user accounts.

The user list is given in frame (1). Selecting one of active users, general information are shown in frame (2), account in frame (3) and permissions in frame(4).

Add a new user:
- Click on the Add button, located below the user list (1).
- In the new user window (5), enter the user name and password and confirm the password. You can add a password hint (optional) and notes (optional).
- At the bottom of the window (5), grant permissions for the user.
- You can associate a picture to the user by the button Associate picture, choosing between a file (Browse) or acquiring a new image from the webcam (Capture).
- Click on the New button.

Delete a user:
- Select the user to delete.
- Click on the Delete button below the list of users (1).
- Click on the Confirm button in the window (6) to confirm the deletion.

Modify a user:
- Select the user to modify.
- Click on the Edit button below the list of users (1).
- Modify the user data in the window (5).
- Click on the Update button to confirm the changes.
Change the user password:

- Type your user name and password in (3).
- Click on the Change Password button.
- Enter and confirm the new password in the window (7).
- Click on the Update button.
4. **Settings**

This manages the Cardiovascular Suite settings. The buttons at the top of the window provide access to the various setting windows:

- [Settings - General](#)
- [Settings - FMD Studio](#)
- [Settings - Carotid Studio](#)
- [Settings - Security](#)
- [Settings - License Key](#)
- [Settings - Advanced](#)
4.1. Settings - General

The information of the Institute is displayed in frame (1). The folder where the Cardiovascular Suite archive is stored (archive folder) is in frame (2).

**Edit the information of the Institute:**
- Click on the *Edit* button, next to the Institute information (1).
- Change the Institute information in the *Institute* window.
- You can associate a picture to the Institute by the button *Associate picture*, choosing between a file (*Browse*) or acquiring a new image from the webcam (*Capture*).
- Click on the *Update* button to confirm the changes.

**Change the Archive Folder**
- Click on the *Edit* button, next to the Archive Folder (2).
- Choose the new Archive Folder location.

*WARNING: changing the folder location data, the archive may no longer be accessible.*
4.2. Settings - FMD Studio

Frames (1) and (2) contain the settings for an examination of Flow Mediated Dilation: baseline, ischemia, and vasodilation times, the colors of the plots, the colors of the contours, activation and settings of the flow analysis instrument.

Frame (3) contains the settings for an examination of GTN Induced Dilation: baseline and vasodilation times, the colors of the plots, the colors of the contours.

In the frame (4) you can set the Acoustic Alert. In Flow Mediated Dilation, the system provides an audible alert at the end of the baseline (at the time when the cuff must be inflated to create ischemia) and at the end of ischemia (the time when the cuff must be deflated). In GTN Induced Dilation, the system provides an audible alert at the end of the baseline (at the time the vasodilator drug should be administered).

**Change the timing of Flow Mediated Dilation / GTN Induced Dilation:**

- Change baseline, ischemia, and vasodilation times using the buttons or by typing the values in text boxes.
- Click on the Apply button to confirm the changes.

*NOTE: The range of possible values are: baseline [30 ... 120 sec], ischemia [120 ... 480 sec], vasodilation [240 ... 600 sec].*
Change the colors of plots in Flow Mediated Dilation / GTN Induced Dilation:

- Click on the Modify Color button of the section of the plot you want to change.
- Choose the new color.
- Click on the Apply button to confirm the changes.

Change the colors of the contours in Flow Mediated Dilation / GTN Induced Dilation:

- Click on the Modify Color button of the contour to be modified.
- Choose the new color.
- Click on the Apply button to confirm the changes.

Set acoustic alerts:

- Select the Acoustic Alert tick box.
- Select the sound in the drop down menu.
- Click on the Apply button to confirm the changes.

Enable / disable the calculation of the shear rate:

- Select / deselect the Shear Rate Detection tick box.

Set the instrument for calculating the shear rate by reading the numerical value generated from your ultrasound system:

- Select Detection by OCR.
- Select the brand-model of the ultrasound system in the drop down menu.
- Click on the Apply button to confirm the changes.

Set the instrument for calculating the shear rate through doppler flow analysis:

- Select Detection by Image Analysis.
- Click on the Edit button and choose the video source that you want to use: select Video device... or Data file...;

X-axis calibration

- Locate, on the x axis of the doppler flow profile, a known time period, which is 4 sec in the example in Figure (15).
- Click on the CALIB button (6).
- Select the x-axis calibration (7).
- Select from the drop-down menu (9), the time period specified above.
- Plot on the x axis of the doppler flow profile, a line corresponding to the time period specified above: click on one point end and drag the mouse to the other extreme (press the Shift key on your keyboard to force the tracing of a horizontal line).
Y-axis calibration

- Locate, on the y axis of the doppler flow profile, a known flow amount, which is 200 cm/sec in
  the example in Figure (16).
- Click on the CALIB button (6).
- Select the y-axis calibration (8).
- Select from the drop-down menu (10), the flow amount specified above.
- Plot on the y axis of the doppler flow profile, a line corresponding to the flow amount specified
  above: click on one point end and drag the mouse to the other extreme (press the Shift key on
  your keyboard to force the tracing of a vertical line).

Drawing the Doppler Flow ROI

- Click on the ROI button (5).
- Click on a corner of the doppler flow profile and drag until the Doppler Flow ROI is complete.
- As you draw the Doppler Flow ROI, the system automatically draw also the trace of the doppler
  flow profile (in cyan) and the zero line (in green).

Changing the Doppler Flow ROI

- Click on one of the corners of the Doppler Flow ROI: the scaling handles (white circles) appear.
- Drag the scaling handles to change the size of the the Doppler Flow ROI.

Upon completion, the value of the average velocity (cm/sec) is displayed by the display (11) and the
  calibration values are displayed by the display (12).

Sensitivity adjustment

Use the slider (13) to adjust the sensitivity of the Doppler flow analysis tool. The sensitivity value
  is shown on the display (14).
- Close the window with the red button in the upper right.
- Click on the Apply button to confirm the changes.
4.3. Settings - Carotid Studio

Contains software settings for Carotid Studio:
- the time used for analysis.
- the colors of the contours for both the Lumen-Intima and the Media-Adventitia interfaces.

**Change the time of analysis:**
- Change the time of analysis using the button or by typing the value in the text box. 5.
- Click on the Apply button to confirm the changes.

*NOTE: The range of possible values is: [5...30sec].*

**Change the colors of the contours**
- Click on the Modify Color button of the contour to be modified (Lumen-Intima or Media-Adventitia).
- Choose the new color.
- Click on the Apply button to confirm the changes.
Contains the security settings of the suite. Frame (1) contains the backup options for the database structure. In frame (2), set *Automatic Login as Administrator* to automatically enable the administrator login when the program starts (you no longer need to enter your login and password in the home screen). The option *Lock Study Changes after...* prevents to make changes to a study after a given number of days since its creation.

**Set the backup options for the database structure**

- Select *When closing application* to backup the database structure every time the application is close.
- Select *Every* and type a value N in the text boxes to backup the database structure every N days.
- Select *On Demand* to backup the database structure every time the *Backup Now* button is pressed.

**Enable / disable automatic login as administrator**

- Select / deselect the *Automatic Login as Administrator* tick box.
- Click on the *Apply* button to confirm the changes.

**Lock / unlock the changes of the studies**

- Select / deselect the *Lock Study Changes after...* tick box.
- Change the number of days after which the study can not be modified using the button or by typing the value in the text boxes.
- Click on the *Apply* button to confirm the changes.
4.5. Settings - License Key

Contains information on software license and allows you to change the license. **WARNING: changing the software license will cancel the original license. Make sure to have a valid license.**

![](image)

Set a new license
- Click on the *Change License Key...* button.
- Click on the *Proceed* button to confirm the removal of the old license.
- In *Cardiovascular Suite Registration* window, enter the name of the person/institution that is registering the product and enter the license key. Confirm with *Register*.
- Click on the *Apply* button to confirm the changes.
4.6. Settings - Advanced

**WARNING:** an incorrect setting of these parameters could affect the proper functioning of the system.

Frame (1) shows the setting of the video files recorded by Cardiovascular Suite when using the live video source. You can choose the codec and the quality of the video files.

Frame (2) contains the recording time of temporary video files used by Carotid Studio. This time corresponds to the maximum time available to perform a single measure of Carodid Analysis.

*Change the maximum recording time*

- Change the recording time by using the button.
- Click on the Apply button to confirm the changes.

*NNOE: The range of possible values is: [60...720sec].*
5. Archive

The left frame of the window contains the list of studies. The studies can be shown in list or icons view.

Each study is identified by a folder icon or , the latter when the study size has been optimized. Next to the icon (in the list view) or below the icon (the icon view) are some of the data from the study: patient name, sex, modality of the examination (FMD, GTN, CAR), date of creation of the examination, examination time.

When you select one of the studies, the right frame of the window shows the contents of the study. The upper part shows the name of the patient, the performing physician, the institute, the modality and the duration of the study. You can click on the fields Patient, Performing physician and Institute to modify the data. Clicking on more info... you can change the study code, keywords, notes, and description of the study. The upper part of the frame contains the list of documents of the study. Each document is identified by an ultrasound image icon . Next to the icon are some of the data in the document. These data vary depending on the examination modality.
5.1. Displaying grouped studies
The studies can be grouped according to five criteria:
1. by patient.
2. by performing Physician.
3. by Institute.
4. by examination modality.
5. by study code.

When studies are grouped, the left frame of the window contains the list of groups. Each group can be expanded to display the list of studies contained within it. You can choose a default view that will be used each time you access the archive.

**Group studies**
- Click on the *Menu* button.
- Select *Group studies by...*
- Select the grouping criteria

**Choose the view mode**
- Click on the *Menu* button.
- Select *View as...*
- Select the list view or the icons view.

**Set the default view**
- Choose the preferred grouping mode and view mode.
- Click on the *Menu* button.
- Select *Save default view.*

5.2. Managing Studies
This section describes how export and import the studies from Cardiovascular Suite, how to optimize the size of a study and how to delete a study.

**Importing a study**
- Click on the *Menu* button.
- Select *Import study.*
- Select the folder containing the study to be imported.
- Click on the *Choose* button.
Exporting a study
- Select the study to be exported.
- Click on the Menu button.
- Select Export study.
- Select the folder where to export the study.
- Click on the Choose button.

Using the Add and Remove buttons
The buttons Add and Remove have different meanings depending on how the studies are grouped and depending on what is selected in the left frame of the Archive window. Hint: Use the pop up message of the button to check the meaning.

Optimizing the study size
- Select the study to be optimized.
- Right click and select Optimize Study Size

Removing a study
- Select the study to be removed.
- Right click and select Remove Study.
- Confirm with Delete.

5.3. Export Aggregate Results
Results from a group of studies can be aggregated and exported in a single data file. This feature is active only when the studies are not grouped (see section 5.1).

Exporting Aggregate Results
- Select the studies whose data is to be exported.
- Click on the Menu button.
- Select Export Aggregate Results.
- Choose the folder where to export the file and press the Save button.
6. **New Study**

Create a new study. Required fields are in red. The *New Study* button is disabled until you have entered all the required data.

- **Create a new study**
  - Enter the patient personal data into the frame (1).
  - In frame (2), enter the study information and choose the modality of: Flow Mediated Dilation; GTN Induced Dilation; Carotid Studio.
  - Enter the name of the performing physician into the frame (3). If the name is already present in the archive, it will be in the drop-down menu. Otherwise you can type name (middle name) and last name, separated by a space.
  - Enter the name of the Institute into the frame (4). If the Institute is already present in the archive, it will be in the drop-down menu. Otherwise you can type the name of the Institute.
  - In frame (5), choose the video source between *Video Device* (for external source, such as ultrasound equipment) or *Video File* (in the case of data recorded on a digital medium, eg. Flash pen drive, hard disk, CD ROM). Video files can be in video formats supported by QuickTime or DICOM 3.
  - Click on the *New Study* button on the bottom right of the window (6).
7. Flow Mediated Dilation

Make an examination of Flow Mediated Dilation.

Components description:
1. Video window
2. Controls panel
3. Data display
4. Instantaneous diameter chart
5. Mean diameter chart
6. Shear rate chart (Note: the chart is present only if you selected Shear Rate Detection in Settings – FMD Studio)
The video window shows the video signal from your ultrasound system. Two ROIs (1) (2) are present in the window: the diameter ROI and the doppler flow ROI (*). The video controls bar is at the bottom of the window (3).

(*) The doppler flow ROI is present in Flow Mediated Dilation exams only if the Shear rate detection options is selected in Settings - FMD Studio.
7.2. Diameter ROI
The Diameter Region of Interest (ROI) is the portion of the image where the diameter is calculated. Two edges of the vessel obtained by the algorithm of edge detection are displayed within the ROI. The ROI can be moved and/or resized. Each time you change the position and/or size of the ROI, the contours of the vessel are re-initialized.

![Diameter ROI](image)

**Draw a new ROI:**
- Click on the ROI button in the Control panel (button remains active).
- Click inside the video window and drag until the ROI is complete (the size of ROI is shown into the Data display).
- When you release the mouse, the contours are initialized, the ROI button in the Control Panel is disabled, the PROCESS button in the Control Panel becomes active and processing starts.

**Change the ROI:**
- Click on one of the corners of the Diameter ROI: the scaling handles (white circles) appear.
- Drag the scaling handles to change the size of the Diameter ROI (the size of ROI is shown into the Data display).

**Move the ROI:**
- Click and hold inside the ROI.
- Drag the ROI to the location of interest.

**Re-initialize the edge detection algorithm:**
- Click into the ROI.
7.3. Doppler Flow ROI

The Doppler Flow Region of Interest is present in the video window if the PROCESS button of the Control Panel is pressed and the Shear rate detection options is selected in Settings - FMD Studio. The Doppler Flow ROI can be moved or resized. The perimeter of the ROI-flow is drawn in red, the zero line is drawn in green, the doppler flow profile is drawn in cyan.

Change the ROI:
- Click on one of the corners of the Doppler Flow ROI: the scaling handles (white circles) appear.
- Drag the scaling handles to change the size of the the Doppler Flow ROI.

Move the ROI:
- Click and hold inside the ROI.
- Drag the ROI to the location of interest.
7.4. Video controls bar

The video control bar is at the bottom of the video window and contains controls to manage the playback of a movie and the brightness and contrast adjustment.

Adjust the image
- Drag the brightness slider to adjust the brightness of the image.
- Drag the contrast slider to adjust the contrast of the image.

Control the playback of a movie
- Click on the Play/Pause buttons to play/pause the movie;
- Click on the Step forward button to advance an image;
- Click on the Step backward button to move back one image;
- Click on the End button to move forward until the end of the movie;
- Click on the Start button to return to the beginning of the movie;
- Drag the time slider to move to any part of the movie.
7.5. Control Panel

The control panel allows you to perform the operations necessary to carry out an examination of Flow Mediated Dilation.

**Description of the controls:**
1. CALIB: enters in calibration mode.
2. ROI: draw a new diameter ROI.
3. PROC: enable/disable the image processing.
4. REC: enable/disable recording.
5. RESET: remove the current registration.

**Warning about duration of the video source**
A warning message will be shown under the Control panel in the case where the source used is a video file and its duration is shorter than the *Recording time* set in the **Settings - FMD Studio**.

![Warning message]

**WARNING! The duration of the selected data source is shorter than the Recording Time (Current 145 sec., Required 600 sec.)**
7.6. Calibration

The calibration must be done before starting a new examination because it is necessary to provide information about the size of the image generated by ultrasound system. The calibration factor changes depending on the settings of your ultrasound machine. You can save a default calibration value that will be used when you start a new examination. However, you should redo the calibration at each new examination. **WARNING: the lack of calibration can generate a software malfunction.**

**Calibrate**
- Locate, in ultrasound image, a range of known distance (10 mm. in the example of figure).
- Click on the **CALIB** button (1) in the Controls panel (button remains active).
- Select from the drop-down menu (7), the distance specified above.
- Draw a line on the image corresponding to the known distance: click on one end and drag the mouse to the other extreme (press the Shift key on your keyboard to force the tracking of a vertical or horizontal line).

![10mm Calibration Line](image)

**Save a default calibration value**
- Perform the calibration.
- Click on the **Save as default** button (6)
7.7. Data Display

The data display shows the results of the examination

Description of the display data:
1. CAL: calibration factor [pixel/mm]. If you have not already calibrated, the display shows the value of default calibration in red.
2. ROI: size (width, height) of the Diameter Region of Interest [mm].
3. SR: shear rate [s⁻¹]. (*)
4. DIAM: mean diameter [mm].
5. TIME: exam time [minutes: seconds]

(*) The shear rate is present only if the Shear rate detection options is selected in Settings - FMD Studio.

7.8. Instantaneous diameter chart

This chart shows the diameter changes within the cardiac cycle. The correct form of this chart is an index of measurement quality. The chart will automatically scale and the values shown are the extremes of the scale.
7.9. Mean diameter chart

The chart shows the trend of the mean diameter during the examination. The chart is divided into three parts: basal (1), ischemia (2) and vasodilation (3). The timing and the colors of the three parts can be customized in Settings - FMD Studio.

Using the buttons at the bottom right (4) you can move up or down the chart, enlarge or reduce the vertical scale.

7.10. Shear rate chart

The graph shows the trend of the shear rate during the examination. The chart is divided into three parts in a similar manner to the graph of the mean diameter.
8. FMD Document

The document produced by an examination of Flow Mediated Dilation consists of the following parts:
1. Mean diameter chart.
2. Shear rate chart.
3. Video window.
4. Results display.

Export the document.
- Click on the Study Actions button at the bottom right corner of the document.
- Select Export document as...
- Choose the format in which you want to export.
- Choose the folder where to export the file and press the Save button.

Export data.
- Click on the Study Actions button at the bottom right corner of the document.
- Select Export data as...
- Choose the format in which you want to export.
- Choose the folder where to export the file and press the Save button.

Print the document.
- Click on the Study Actions button at the bottom right corner of the document.
- Select Print.
8.1. Mean diameter chart

The graph shows the trend of the mean diameter during the examination. The chart is divided into three parts: basal, ischemia, and vasodilation.

On the chart there are three horizontal cursors that represent: the value of the baseline diameter (1), the maximum diameter during vasodilation (2), the value of the baseline diameter after vasodilation (3). The cursors can be moved vertically by clicking and dragging with the mouse.

Pressing the ALT key on the keyboard and moving the mouse along the curve of the diameter, you will see the value of the diameter at the point. Simultaneously pressing ALT and CMD, will show both the value of the diameter and the value of time.

Using the buttons at the top right (4) you can move up or down the chart, enlarge or reduce the vertical scale. The chart can be moved up and down also by using the scroll bar located on the right of the graph (5).

Top Left (6) are: the Cut button to remove diameter values that are considered outliers; the Undo button to cancel previous operation and the Sync button to display the movie video clip synchronize with the data.
8.2. Shear rate chart

The chart shows the trend of the shear rate during the examination. The chart is divided into three parts: basal, ischemia, and vasodilation.

On the chart there are three cursors that represent: the value of the baseline shear shear rate (1), this slider is also represented in vasodilation that delimits the area under the curve; the maximum shear rate during vasodilation (2); the time corresponding to the maximum value of the diameter (3), this cursor defines the area under the curve up to the maximum diameter. The cursors can be moved vertically or horizontally by clicking and dragging with the mouse.

Pressing the ALT key on the keyboard and moving the mouse along the curve of the shear rate, you will see the value of the shear rate at the point. Simultaneously pressing ALT and CMD, will show both the value of the shear rate and the value of time.

Remove the outliers
The procedure allows you to manually delete the values that are considered outliers. The same procedure is applicable both to the graph of the mean diameter and to the graph of the shear rate.

- Click on the Cut button located on upper left of the graph of the mean diameter.
- Click on one of the two extremes of the range to delete.
- Drag the mouse horizontally to the other extreme of the range to delete.

*Note: If you wish to cancel, press the Undo button.*

*Note: To save changes to the document, press the Save document button.*

Move the cursors
The cursors of both the mean diameter chart and the shear rate chart can be shifted manually. The shift is affects the results shown in the results display.

- Click with left mouse button to move the cursor.
- Hold down the mouse button and drag the mouse to the new location.
- Release the left mouse button.
8.3. Results display
The display shows the results of the examination.

![Results display image]

Description of the results display:
1. *D Baseline [mm]*: value of the baseline diameter.
2. *D Maximum [mm]*: value of the maximum diameter during vasodilation.
3. *D Recovery [mm]*: diameter value in the recovery phase after vasodilation.
   \[
   FMD = \frac{D_{massimo} - D_{basale}}{D_{basale}}
   \]
5. *FMDr [%]*: Flow Mediated Dilation calculated in relation to the diameter in the recovery phase after vasodilation.
   \[
   FMDr = \frac{D_{massimo} - D_{recupero}}{D_{recupero}}
   \]
6. *SR Baseline [s⁻¹]*: baseline value of the shear rate.
7. *SR Maximum [s⁻¹]*: maximum value of the shear rate.
8. *SR Area [dimensionless]*: area under the curve of the shear rate, calculated for the range of vasodilation and with reference to the baseline value of the shear rate.
9. *SR Area to max [dimensionless]*: area under the curve of the shear rate, calculated from the end of ischemia at maximum vasodilation, and with reference to the baseline value of the shear rate.
10. *CAL [pixel/mm]*: calibration factor.
8.4. Video window

The video window shows the video signal from the ultrasound system and the computed contours. Using the video controls bar, which is located at the bottom of the window, you can control playback of your movie and adjust the brightness and contrast.

You can expand the video window by right clicking and choosing Detach Video Window. The movie will be expanded in a floating window that overlays the FMD document. Moving the mouse outside the video window, this will become translucent allowing you to see the underlying FMD document.

**Synchronize video and data**

1. Press the Sync button, located on the upper left of the mean diameter chart. The mean diameter charts and the shear rate charts will show a yellow marker that identifies the current time on the video window.
2. Click the mouse and drag the yellow marker to navigate using the chart.
3. Use the video control bar to navigate using the video window.
9. GTN Induced Dilation

Make an examination of GTN Induced Dilation

Components description:
1. Video Window (*)
2. Controls panel (*)
3. Data display (*)
4. Instantaneous diameter chart (*)
5. Mean diameter chart

(*) For a description of these parts, see sections 7.1, 7.5, 7.7 and 7.8 of this manual.
The chart shows the trend of the mean diameter during the examination. The chart is divided into two parts: basal (1) and vasodilation (2). The timing and the colors of the three parts can be customized in Settings - FMD Studio.

Using the buttons at the bottom right (3) you can move up or down the chart, enlarge or reduce the vertical scale.
10. GTN Document

The document produced by an examination of GTN Induced Dilation consists of the following parts:
1. Video window. (*)
2. Mean diameter chart.
3. Results display.

(*) For a description of this part, see section 8.4 of this manual.

Export the document.

- Click on the Study Actions button at the bottom right corner of the document.
- Select Export document as...
- Choose the format in which you want to export.
- Choose the folder where to export the file and press the Save button.

Export data.

- Click on the Study Actions button at the bottom right corner of the document.
- Select Export data as...
- Choose the format in which you want to export.
- Choose the folder where to export the file and press the Save button.

Print the document.

- Click on the Study Actions button at the bottom right corner of the document.
- Select Print.
The graph shows the trend of the mean diameter of the diameter during the examination. The chart is divided into two parts: basal and vasodilation. On the chart there are two horizontal cursors that represent: the value of the baseline diameter (1) and the maximum diameter during vasodilation (2). The cursors can be moved vertically by clicking and dragging with the mouse. Pressing the ALT key on the keyboard and moving the mouse along the curve of the diameter, you will see the value of the diameter at the point. Simultaneously pressing ALT and CMD, will show both the value of the diameter and the value of time.

Using the buttons at the top right (3) you can move up or down the chart, enlarge or reduce the vertical scale. The chart can be moved up and down also by using the scroll bar located on the right of the graph (4).

Top right (3) are also: the Cut button to remove diameter values that are considered outliers; the Undo button to cancel previous operation and the Synch button to display the movie video clip synchronize with the data.

**Remove the outliers**
The procedure allows you to manually delete the values that are considered outliers.

- Click on the Cut button located on upper right of the graph of the mean diameter.
- Click on one of the two extremes of the range to delete.
- Drag the mouse horizontally to the other extreme of the range to delete.

*Note: If you wish to cancel, press the Undo button.*

*Note: To save changes to the document, press the Save document button.*

**Move the cursors**
The cursors of the mean diameter chart can be shifted manually. The shift is affects the results shown in the results display.

- Click with left mouse button to move the cursor.
- Hold down the mouse button and drag the mouse to the new location.
- Release the left mouse button.
10.2. Results Display

The display shows the results of the examination.

![Results Display Image]

**Description of the results display:**

1. **D Baseline [mm]:** value of the baseline diameter.
2. **D Maximum [mm]:** value of the maximum diameter during vasodilation.
3. **GTN [%]:** GTN Induced Dilation. \( \text{GTN} = \frac{D_{\text{maximum}} - D_{\text{baseline}}}{D_{\text{baseline}}} \)
4. **CAL [pixel/mm]:** calibration factor.
11. Carotid Analysis
Make an examination of carotid analysis.

Components description:
1. Video window
2. Controls panel
3. Data display
4. Pressures panel
5. Diameter chart
6. IMT chart
11.1. Video window

The video window shows the video signal from your ultrasound system and the ROI (1) where both the IMT and the diameter are computed. The video controls bar is at the bottom of the window (2).
11.2. Region of Interest (ROI)

The Region of Interest (ROI) is the portion of the image where both the diameter and the IMT are calculated. Within the ROI, the Lumen-Intima interface and the Media-Adventitia interface are shown in the colors set in Settings - Carotid Studio. The ROI can be moved and/or resized.

**Draw a new ROI:**
- Click on the ROI button in the Controls Panel (button remains active).
- Click inside the video window and drag until the ROI is complete (the size of ROI is shown into the Data display).
- When you release the mouse, the contours are initialized, the ROI button in the Control Panel is disabled, the PROCESS button in the Controls Panel becomes active and processing starts.

**Change the ROI:**
- Click on one of the corners of the Diameter ROI: the scaling handles (white circles) appear.
- Drag the scaling handles to change the size of the the Diameter ROI (the size of ROI is shown into the Data display).

**Move the ROI:**
- Click and hold inside the ROI.
- Drag the ROI to the location of interest.
11.3. Controls panel

The control panel allows you to perform the operations necessary to carry out an examination of Carotid Analysis.

*Description of the controls:*
1. CALIB: enters in calibration mode.
2. ROI: draw a new ROI.
3. SAVE: save data.
4. RESET: remove the current registration.

*Warning about duration of the video source*
A warning message will be shown under the Controls panel in the case where the source used is a video file and its duration is shorter than the *Time of analysis* set in the [Settings - Carotid Studio](#).
11.4. Calibration

The calibration must be done before starting a new examination because it is necessary to provide information about the size of the image generated by ultrasound system. The calibration factor changes depending on the settings of your ultrasound machine. You can save a default calibration value that will be used when you start a new examination. However, you should redo the calibration at each new examination.

**WARNING:** the lack of calibration can generate a software malfunction.

**Calibrate**

- Locate, in ultrasound image, a range of known distance (10 mm. in the example of figure).
- Click on the CALIB button (1) in the Controls panel (button remains active).
- Select from the drop-down menu (6), the distance specified above.
- Draw a line on the image corresponding to the known distance: click on one end and drag the mouse to the other extreme (press the Shift key on your keyboard to force the tracking of a vertical or horizontal line).

![Calibration Diagram]

**Save a default calibration value**

- Perform the calibration.
- Click on the Save as default button (5)
11.5. Data display
The data display shows the results of the examination

Description of the display data:
1. CAL: calibration factor [pixel/mm]. If you have not already calibrated, the display shows the value of default calibration in red.
2. ROI: size (width, height) of the Diameter Region of Interest [mm].
3. DIAM: mean diameter [mm].
4. TIME: exam time [minutes: seconds]

11.6. Pressures panel

In this panel you can enter the values of diastolic and systolic pressure [mmHg].
11.7. Diameter chart

![Diameter Chart](image)

This chart shows the diameter changes within the cardiac cycle. The extension of the time scale is equal to the *Time of analysis*, set in *Settings - Carotid Studio*.

11.8. IMT chart

![IMT Chart](image)

This chart shows the IMT small changes within the cardiac cycle. The extension of the time scale is equal to the *Time of analysis*, set in *Settings - Carotid Studio*. 
11.9. Processing a carotid scan.

Once you place an ROI, the system begins to process the images automatically updating the Data display, the Diameter chart and the IMT chart. When the quality of the results is satisfactory, the user can press the Save button on the Controls panel to save the last seconds of processed data. The duration of the time of analysis can be set from Settings - Carotid Studio. You can save different sequences of data within the same study. Each sequence of data will be saved in a document of the study.

**Acquisition of a sequence of data**

1. Make sure you have previously calibrated.
2. Place the ROI.
3. Wait until the analysis is satisfactory.
4. Click on the Save button in the Controls panel.
5. Check the diameter chart and the IMT chart are satisfactory.
6. If so, enter a description of the sequence data and press Save. Otherwise press the Delete button.
12. Carotid Analysis Document

The document produced by an examination of Carotid Analysis consists of the following parts:
1. Diameter chart.
2. IMT chart.
3. Video window.
4. Results display.

Export the document.

- Click on the Study Actions button at the bottom right corner of the document.
- Select Export document as...
- Choose the format in which you want to export.
- Choose the folder where to export the file and press the Save button.

Export data.

- Click on the Study Actions button at the bottom right corner of the document.
- Select Export data as...
- Choose the format in which you want to export.
- Choose the folder where to export the file and press the Save button.

Print the document.

- Click on the Study Actions button at the bottom right corner of the document.
- Select Print.
12.1. Diameter chart

The graph shows the trend of the diameter during the examination. Pressing the ALT key on the keyboard and moving the mouse along the curve of the diameter, you will see the value of the diameter at the point. Simultaneously pressing ALT and CMD, will show both the value of the diameter and the value of time.

Top Left (6) are: the Cut button to remove diameter values that are considered outliers; the Undo button to cancel previous operation and the Sync button to display the movie video clip synchronize with the data.

Remove the outliers
The procedure allows you to manually delete the values that are considered outliers.

- Click on the Cut button located on upper left of the graph of the diameter.
- Click on one cardiac cycle to delete.

*Note: If you wish to cancel, press the Undo button.*

*Note: To save changes to the document, press the Save document button.*
12.2. IMT chart

The graph shows the trend of the IMT during the examination. Pressing the ALT key on the keyboard and moving the mouse along the curve of the IMT, you will see the value of the IMT at the point. Simultaneously pressing ALT and CMD, will show both the value of the IMT and the value of time.

Remove the outliers
The procedure allows you to manually delete the values that are considered outliers.

◆ Click on the Cut button located on upper left of the graph of the diameter.
◆ Click on one of the two extremes of the range to delete.
◆ Drag the mouse horizontally to the other extreme of the range to delete.

*Note: If you wish to cancel, press the Undo button.*

*Note: To save changes to the document, press the Save document button.*
12.3. Results display

Description of the contents of the results display:

1. **Mean diameter [mm]**: value of the average diameter.
2. **Distension [mm]**: stroke change in diameter.
   \[
   \text{Distension} = \Delta D = D_s - D_d
   \]
3. **IMT [mm]**: Intima media Thickness.
4. **Blood pressure [mmHg]**: Dia = diastolic pressure; Sys = systolic pressure.
5. **Compliance \([10^{-6} \cdot m^2 \cdot kPa^{-1}]\)**: absolute change in lumen area during systole for a given pressure change.
   \[
   \text{Compliance} = \frac{\Delta A}{\Delta P} = \frac{\pi}{4} \cdot \frac{D_s^2 - D_d^2}{P_s - P_d}
   \]
6. **Distensibility \([10^{-3} \cdot kPa^{-1}]\)**: relative change in lumen area during systole for a given pressure change.
   \[
   \text{Distensibility} = \frac{1}{A_d} \cdot \frac{\Delta A}{\Delta P} = \frac{1}{D_d^2} \cdot \frac{D_s^2 - D_d^2}{P_s - P_d}
   \]
7. **Carotid Stiffness \([m \cdot s^{-1}]\)**: Stiffness value computed by Bramwell-Hill equation.
   \[
   \text{Stiffness} = \frac{1}{\sqrt{\rho \cdot \text{Distensibility}}} = \frac{\sqrt{A_d \cdot \Delta P}}{\rho \cdot \Delta A} = \frac{\sqrt{D_s^2 \cdot (P_s - P_d)}}{\rho \cdot \sqrt{D_s^2 - D_d^2}}
   \]
8. **Young’s elastic module [kPa]**:
   \[
   \text{ModuloYoung} = \frac{3}{\text{Distensibility}} \left(1 + \frac{A_d}{WCSA}\right)
   \]
9. **CAL [pixel/mm]**: calibration factor.

Note:

\(D_e\) = External Diameter (between the media-adventitia interfaces) measured in diastole.

\(D_i\) = Internal Diameter (between the lumen-intima interfaces) measured in diastole.
where:

\( D_s \) = Systolic Diameter (external).
\( D_d \) = Diastolic Diameter (external), \( D_d = D_e \).

\[ WCSA = \frac{\pi}{4} \cdot (D_e^2 - D_i^2) \] = Wall Cross Section Area.

\[ \Delta D = D_s - D_d = \text{Stroke change in diameter.} \]

\[ \Delta A = \frac{\pi}{4} \cdot (D_s^2 - D_d^2) = \text{Stroke change in lumen area.} \]

\[ A_d = \frac{\pi}{4} \cdot D_d^2 = \text{Diastolic Area.} \]

\( P_s \) = Systolic Pressure.
\( P_d \) = Diastolic Pressure.
\( \rho \) = Blood density: is assumed to be constant and equal to 1.06 g/cm\(^3\).
13. References

13.1. Papers


13.2. Contacts

<table>
<thead>
<tr>
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13.3. Notes

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