REC_IFU_20210728_2- ArtFun+ IFU

ArtFun+ Instructions For Use		IMAGEENS PRECISION MEDICINE IN CARDIOVASCULAR HEALTH
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Document Validation

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1 General Informations

ArtFun+ is a class I medical device manufactured by IMAGEENS.

Below are the different informations related to the manufacturer of this device:

Manufacturer Legal Adress	42 Rue de Maubeuge 75009 Paris
Company's main office	23 Avenue d'Italie 75013 Paris
E-mail address	hello@imageens.com
Internet Website	https://www.imageens.com/

1.1 Intended Use

ArtFun+ is intended to be used for viewing, post-processing, and quantitatively evaluating Magnetic Resonance Images (MRIs) of the following type: aortic cine 2D+t (sequence of 2D images over time) Steady-State Free Precession (SSFP), aortic cine 2D+t Phase Contrast (PC) and thoracic 3D SSFP in a DICOM standard format.

It allows the calculation of MRI Distensibility and aortic arch MRI Pulse Wave Velocity.

This information could be used by medical imaging healthcare professionals, in conjunction with the patient's clinical history/symptoms/other diagnostic tests/physician's professional judgment, in the context of cardiovascular health surveillance, for the assessment of the general cardiovascular risk of the patient.

It is given as general information and shall not be used for diagnosis or treatment activities.

The device is intended to be use by Medical imaging professionals trained in examining & evaluating Cardiac MRI for general patient population between 45 and 84 years old.

1.2 Contrindication, precautions and warnings

No contraindications have been identified for ArtFun+.

Used MRI images must be compliant with DICOM standard and DICOM fields must not have been modified other than for anonymising patient-related information.

The exported results database files must be closed and not used by any other applications during the use of ArtFun+ to prevent corrupting the database.

2 Technical Requirement

In order to guarantee the proper functioning of the device, it is necessary to ensure that the computer operating ArtFun+ meets the criteria listed below:

Criteria	Requirement
Computer Processor	Dual Core Intel i5 ou supérieur, d'architecture 7th-gen/Kaby Lake or higher OR Apple M1
Computer Memory	8 Go de RAM of higher
Computer OS	MacOS BigSur (v11.0 à v11.5)
Application previously installed	Osirix v11 or higher OR Horos v3.3 or higher

An internet connection of 100 Mb or more is also required when first activating the product license and at each start for license validation.

3 Getting started with ArtFun+

3.1 Installation

ArtFun+ software was designed as a plugin for Osirix and Horos.

Ensure the previously mentionned version of Horos OR Osirix is installed.

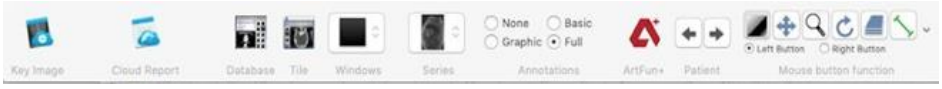
Unzip and launch the installer file by double click.

Osirix / Horos will start and ask you if want to install the plugin. You might be asked for your system password by macOS to allow the installation.

Osirix or Horos will ask you to restart to complete the installation.

After a restart of Osirix/Horos, you will find the plugin in the menu "Plugins" ► "Image Filters".

In the Osirix/Horos 2D Viewer panel, go in the menu "Format" ► "Customize Toolbar and drag&drop ArtFun+ into the usual toolbar to create a shortcut to ArtFun+,



☹ If the plugin is still missing, it may have been wrongly installed. You can check if Horos/Osirix find it in the “Plugins” ► “Plugins Manager” ► “Installed Plugins” tab.

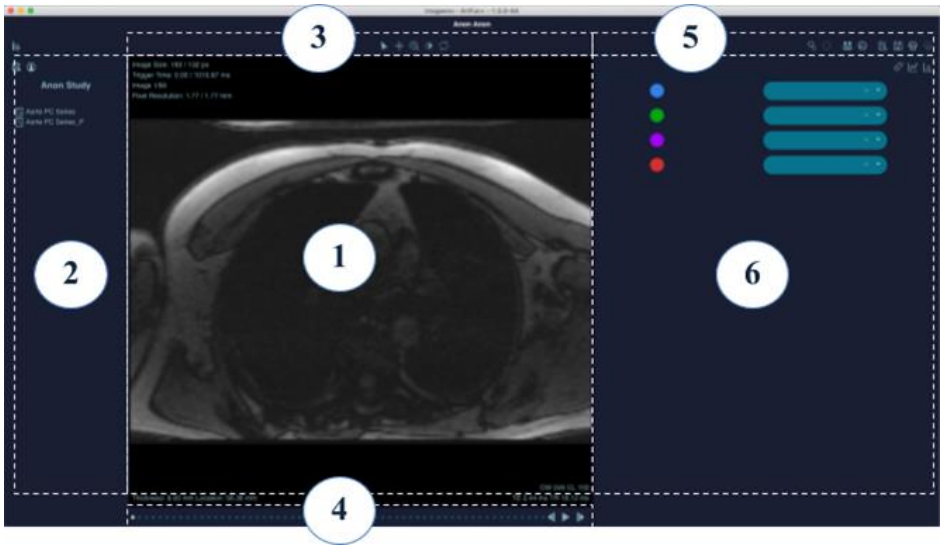
☹ For the uninstallation, open the "Plugin Manager" of Osirix or Horos (Plugins ► Plugin Manager). Select the plugin and uninstall it with the "Uninstall selected plugin" button.

3.2 Start the plugin : Get a license key

1. Start the plugin via the plugin menu item (Plugins ► Image Filters ► ArtFun+), from the 2D Osirix/Horos Viewer panel, or from your own shortcut on the toolbar.
    - If your computer is a Mac with an M1 processor and you don’t have the Rosetta library installed, you will be prompted to install this library. This action is required for M1 Mac to be able to run ArtFun+.
    - If it is the first time you launch the plug-in you might be prompted, through a pop-up, to allow the plug-in to access your data.
2. The application prompt for the license key to activate the plugin
3. If you don’t have one, you can request it by filling your email address in the first field and sending it through the “Request activation” button. We will receive your demand, and contact you by email for the license key.
4. Once you have your license key, paste it in the second field and unlock the plugin through the “Activate license” button
5. The plugin is unlocked: you may have to click on it again in Osirix/Horos to get your first image.

4 ArtFun+ Layout

Once the plugin is activated and you launch it from Osirix/Horos Toolbar, you will be directed to the ArtFun+ User Interface (UI).



(1) Viewer: images are displayed here

(2) Metadata panel: Find patient and study information

(3) Viewer controls: Basic navigation tools

(4) Time frame / anatomical position slider: Select which time point or anatomical position to display in viewer

(5) Workflow controls: tools used for the analysis process

(6) Results panel: ROI labeling, graph charts and clinical indices

In both (2) and (6) panels you can navigate in several sub panels by clicking on the different icon on the top

4.1 Viewer

The Viewer display different images from a specific 2D+t or 3D series and provide the following information:

Image size	The size in pixels of the current image (columns / rows)
Trigger time	The trigger time (in ms) of the current image and the total sequence time

Image index	The index of the current image and the total number of image
Pixel size	The physical size comprised in a pixel (vertically / horizontally)
Slice thickness	The physical size imaged by the current image
Slice location	The physical relative position of the current image in the sequence
TE	The echo time used in the acquisition of the current image
TR	The repetition time used in the acquisition of the current image
CL & CW	The current color level and window (luminosity and contrast)

4.2 Metadata Panel

The Metadata panel shows information of the series that is currently loaded. There are 2 subpanels that show patient metadata by clicking on the icon **(a)** and study and series identifiers by clicking on the icon **(b)** .

You can expand or diminish the Metadata panel by clicking on the left panel icon **(c)**.



a) Patient metadata:

The following patient information is listed:

Name	Patient’s name as provided by the PatientsName (0010,0010) DICOM field
ID	Patient’s ID as provided by the PatientID (0010,0020) DICOM field
Birth Date	Patient’s birth date as provided by the PatientsBirthDate (0010,0030) DICOM field

Sex	Patient's sex as provided by the PatientsSex (0010,0040) DICOM field
Age	Patient's age as provided by the PatientsAge (0010,1010) DICOM field, in years (y)
Weight	Patient's weight as provided by the PatientsWeight (0010,1030) DICOM field, in kilograms (kg)
Height	Patient's height as provided by the PatientsSize (0010,1020) DICOM field, in meters (m)
Heart Rate	Patient's heart rate as provided by the HeartRate (0018,1088) DICOM field, in beats per minute (bpm)
BMI	Patient's body mass index as provided by the PatientsBodyMassIndex (0010,1022) DICOM field, in kilograms per square meters (kg/m^2)
Body Surface Area	Patient's body surface area, in square meters (m^2)
Carotid SP	Patient's systolic blood pressure measured at the carotid, in millimeter of mercury (mmHg)
Carotid DP	Patient's diastolic blood pressure measured at the carotid, in millimeter of mercury (mmHg)
Carotid PP	Patient's pulse blood pressure calculated as Carotid SP – Carotid DP, in millimeter of mercury (mmHg)
Brachial SP	Patient's systolic blood pressure measured at the brachial artery, in millimeter of mercury (mmHg)
Brachial DP	Patient's diastolic blood pressure measured at the brachial artery, in millimeter of mercury (mmHg)
Brachial PP	Patient's pulse blood pressure calculated as Brachial SP – Brachial DP, in millimeter of mercury (mmHg)
Central SP	Patient's systolic blood pressure measured at the aorta, in millimeter of mercury (mmHg)

Central DP	Patient's diastolic blood pressure measured at the aorta, in millimeter ofmercury (mmHg)
Central PP	Patient's pulse blood pressure calculated as Central SP – Central DP, in millimeter of mercury (mmHg)
Aortic Distance for MRI PWV	Aortic distance between the ascending and descending aorta section for PWV estimation (mm)
Tonometric PWV	Patient's pulse wave velocity measured by tonometry, in meter per second (m/s)
HDL cholesterol	Patient's high density cholesterol level, in millimole per liter (mmol/L)
LDL cholesterol	Patient's low density cholesterol level, in millimole per liter (mmol/L)
Total cholesterol	Patient's total cholesterol level, in millimole per liter (mmol/L)
Framingham score	Patient's Framingham risk score, in percent (%)
Smoker	Indicate if the patient is a smoker
Diabetes	Indicate if the patient has diabetes
High blood pressure	Indicate if the patient has hypertension
Angina	Indicate if the patient has angina
Medical history	Indicate relevant information about the patient's health

If the related information is available from the DICOM metadata of the loaded series, fields will be automatically filed. If not, fields are empty by default.

☺ Most of the patient fields are editable by the user that wants to add relevant information for reporting.

b) Study and series identifiers:

Le nom de l'étude et les noms des séries qui sont actuellement chargés sont affichés.

4.3 Viewers controls

The icons right above the viewer are basic navigation tools to control the display of images.

Icon	Name	Description	Shortcuts
	Default tool	Return to default behavior and cancel any pending action.	Left click + drag onto viewer to move the image. Mouse wheel up/down to zoom in/out. Shift + left click + drag up/down onto viewer to

			adjust contrast, and left/right to adjust luminosity
	Panning tool	Move the field of view	Left click + drag onto viewer to move the image
	Zoom tool	Change the zoom level	Left click + drag up/down onto viewer to zoom out/in
	Luminosity-contrast tool	Change the luminosity and contrast	Left click + drag up/down onto viewer to adjust contrast, and left/right to adjust luminosity
	Reset tool	Reset the view point to initial position	None

4.4 Time frame / anatomical position slider

Le curseur de position temporelle / position anatomique est la barre inférieure située juste en dessous de la visionneuse qui affiche et contrôle le point temporel ou la position anatomique sélectionné(e) (selon le type d'image chargé, respectivement 2D+t ou 3D).

Vous pouvez visionner la séquence image par image en utilisant les boutons "backward"/"forward" ou en cliquant directement sur un point. La séquence peut également être animée dynamiquement en mode cinéma à l'aide des boutons "play"/"stop".

4.5 Workflow controls

The workflow controls are used in the arterial analysis: segmentation, post-processing and reporting functions. The tools shown here are context sensitive such that they will be enabled or disabled depending on which type of MRI sequence is active. Below is a description of the tools shown:

Icon	**Name**	**Description**

	Arterial segmentation	(cine sequence only) Automatic spatio-temporal segmentation of the large vessels, acquired using cine (2D+t) SSFP or PC sequence, relying on our clinically validated algorithm.
	Adjust contour	(cine sequence only) Semi-auto correction of the ROI's contour using a manual template.
	Edit contour	(cine sequence only) Manual correction of the ROI's contour using a paintbrush-like tool.
	Show velocity	(cine PC sequence only) Switch view to the associated phase image displaying the velocities.
	Background correction	(cine PC sequence only) Set a background velocity noise ROI to correct the velocities values.
	Set aorta points	(3D sequence only) Manual setting of aorta centerline points.
	Edit aorta points	(3D sequence only) Correction of the ROI's path by moving already set points.
	Report	Open/close the report tab to review all the results of the current session.
	Export CSV	Open the CSV export window to save the results locally on the computer (files are located on the desktop, in an "ImageensReport" folder)

a) Arterial segmentation (cine sequence only) :

This tool is dedicated to the arterial section segmentation on cine sequence: Ascending aorta, descending aorta or any pseudo-circular section.

1. Draw a rectangle around the arterial section by left click + drag onto viewer
2. An automatic circular initialization is proposed. Accept it if it is correct, or reject it to do a manual initialization. To do so, click one point for the circle center, then one point for the circle ridge.
3. The final segmentation is then automatically computed and displayed as an unlabeled ROI.

b) Adjust contour (cine sequence only) :

If the computed contour is faulty, it can be semi-automatically corrected.

1. Select the desired ROI **before assigning it a label**
2. Click the Adjust Contour button
3. Identify the range of slices where the contour is faulty by selecting the first and the last images
4. Delineate the correct border of ROI on presented first slice and validate
5. Repeat for the presented last slice (only if different from first)
6. Automatic update of the contour is computed based on the manual template given in the two previous steps.

c) Edit contour (cine sequence only):

If the computed contour is faulty, it can be manually corrected.

1. Select the desired ROI
2. Click the Edit Contour button
3. Maintain left click onto the viewer to display the paintbrush tool. The farther from the contour the click, the larger will by the brush.
4. Move the contour by pushing it with the brush tool. To expand contour, click have to be inside contour, to shrink it on the outside
5. If the ROI is labeled, clinical indices are automatically recomputed from corrected contour on the left click release.

d) Background velocity correction (cine PC sequence only):

This tool is used to rectify the velocities values by subtracting the background noise.

1. Click the Background Correction button
2. Design a circular area that represents a non-moving physical part and velocities are artifacts, by two clicks, one for the circle center and one for the circle ridge. Velocity values are automatically recomputed.

e) Set aorta points (3D sequence only):

This tool is dedicated to the creation of an aortic centerline.

1. Pick points in the center of aorta lumen on each slice by a left click
2. Validate once finished
3. The final point set is displayed as an unlabeled ROI.

f) Edit aorta points (3D sequence only):

If the centerline is faulty, it can be manually corrected.

1. Select the desired ROI
2. Click the Edit aorta points button

3. Drag&drop relevant points to their new location
4. If the ROI is labeled, clinical indices are automatically recomputed from corrected path on the left click release.

g) Report

This button displays the reporting tab, a panel that resumes all the results of the current session. The structure is as follow (exhaustive description of indices can be found in the 2.3 section):

- General patient and study information
- Area measurements
- Flow measurements (PC sequence only)
- Transit Time measurement (PC sequence only)
- Value of biomarkers (if previously calculated)

h) CSV Export

This tool allows the results of the session to be saved locally on the current computer. The button displays a window where the user can indicate their estimation of the image quality, their confidence in the measurements, and any useful comments. Click on the Export button in this window to save the results. It generates 5 files located in the "ImageensReport" folder on the desktop:

- ArtFunPlus_Records_VascularResults, containing all clinicals indicators from cine arterial ROIs sorted by record date
- ArtFunPlus_Records_Curves, containing all the curves values from cine arterial ROIs sorted by record date
- ArtFunPlus_Records_ROIs, containing all the coordinates of ROIs in image and patient space from cine arterial ROIs, sorted by record date
- Geometry_Records_LengthResults, containing the arterial length from 3D arterial ROIs sorted by record date
- Geometry_Records_ROIs, containing all the coordinates of ROIs in image and patient space from 3D arterial ROIs, sorted by record date.

All records are identified by date, but also by patient and image information:

- Patient ID
- Patient Name
- Patient Age
- Patient Weight
- Study instance UID
- Series instance UID
- Series Description
- Image Position Patient (image origin in patient space)
- Image Orientation Patient (image orientation in patient space)
- Image Size
- Pixel Spacing

- ITK origin and scaled direction (A+ internal reference system)
- Sequence Type

4.6 Results panel

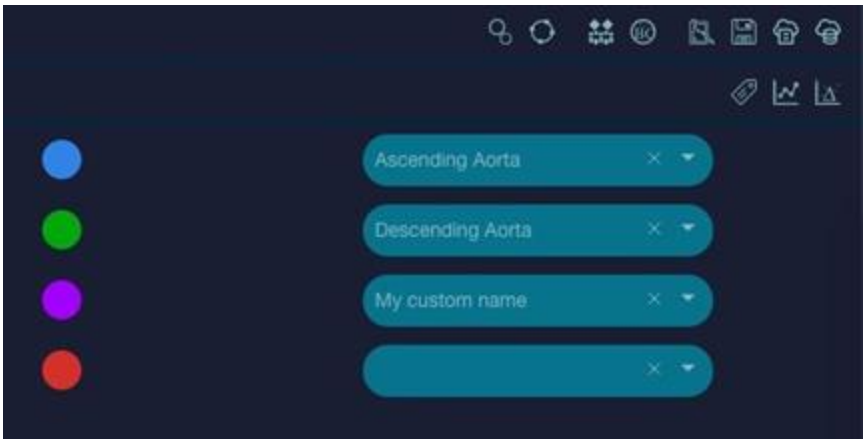
Three sub-panels are provided:

Icon	Name	Description
	ROI labels	Label up to 4 computed ROIs with a color and a name.
	Arterial graphs and indicators	Review the temporal curve of the arterial area during the cardiac cycle, and blood velocity or flow (for PC acquisition), and the main clinical indices automatically calculated on the curves.
	Flow delay estimation	(PC sequence only) Provide the transit time between 2 flow curves (mainly between the ascending and descending aorta)
	Aortic length & 3D view	Review the created centerline as well as the computed aortic length.

a) ROI labels

Up to 4 ROIs can be analyzed concurrently.

1. Select a ROI on the viewer.
2. Select a color disk to assign the color and automatically launch the analysis.
3. Select a name for the ROI among the proposed tags or write a custom one.



b) Arterial graphs and indicators

The top part of the panel displays the graph chart

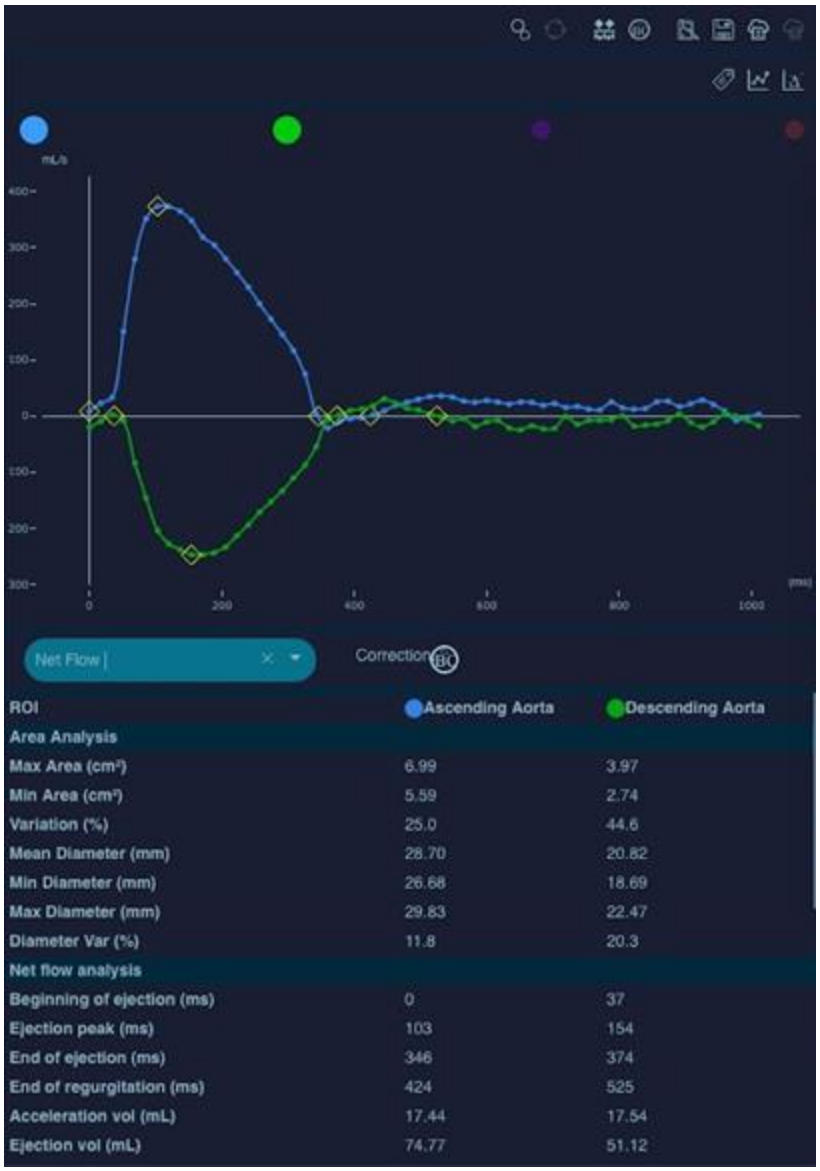
1. Select the desired curve through the drop-down menu below the chart.
2. Select a color disk to hide/show a specific ROI.
3. Hover on the curves to get more information on values

The bottom part of the panel displays the computed clinical indices, concurrent ROIs being displayed by column

1. Review the values by scrolling up/down

Note (PC sequence only): if a background correction has been made, it can be switched on/off in values computation by selecting the icon **(a)** in the central part.

(a)

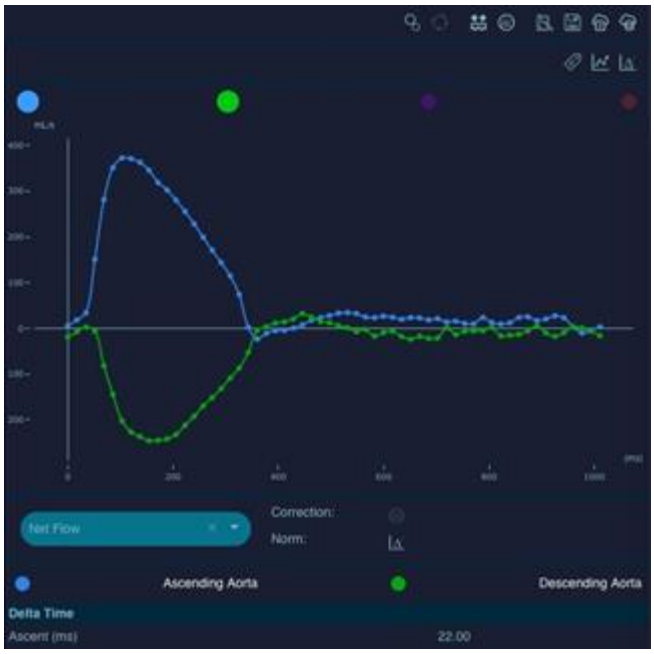


ROI	Ascending Aorta	Descending Aorta
Area Analysis		
Max Area (cm²)	6.99	3.97
Min Area (cm²)	5.59	2.74
Variation (%)	25.0	44.6
Mean Diameter (mm)	28.70	20.82
Min Diameter (mm)	26.68	18.69
Max Diameter (mm)	29.83	22.47
Diameter Var (%)	11.8	20.3
Net flow analysis		
Beginning of ejection (ms)	0	37
Ejection peak (ms)	103	154
End of ejection (ms)	346	374
End of regurgitation (ms)	424	525
Acceleration voi (mL)	17.44	17.54
Ejection voi (mL)	74.77	51.12

c) Flow delay estimation (PC sequence only)

The transit time between a pair of ROIs can be estimated from the flow curves

1. Select the desired pair by clicking on two color disks.
2. Transit time is estimated and displayed on the bottom of the graph.
3. Normalized curves can be displayed to get a better visualization of curve delay.

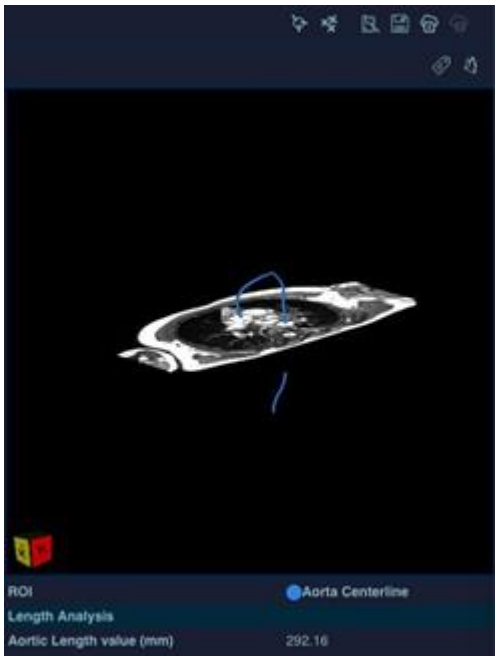


d) Aortic length & 3D view

The top part of the panel displays the 3D view that shows the created centerline over the anatomical slices

1. Rotate the view with a left click
2. Zoom in/out with the mouse wheel or the right click
3. Change the focal point with Shift + left click

The bottom part of the panel displays the computed aortic lengths, concurrent ROIs being displayed by column



4.7 ArtFun+ Pop-Up

There are different types of pop-up windows in ArtFun+. Pop-ups can appear either for information or to indicate that an action is required. These pop-ups are shown below.

a) Informative pop-ups

All the pop-up windows shown below are for information purposes only. No action is required to proceed, however, some pop-ups inform you of an error. It is necessary to take this information into consideration in order to obtain a correct result at the end of the analysis. The steps to be taken to resolve each error pop-up are listed in order of priority below each pop-up below.

1. Loading image in progress
2. Loading error
    a. Check that the image sequence type is supported by ArtFun+. (Cine SSFP or Cine PC or 3D SSFP)
    b. Check that the data are not corrupted or incomplete
    c. Ensure that DICOMs are unzipped
    d. If none of the above steps solves the error message you can contact IMAGEENS via the contacts listed in part 7 of this manual.
3. Error in the automatic creation of the initial circle
    a. This error message will automatically generate the action pop-up "How to perform a segmentation correction manually".
4. Segmentation in progress

5. Segmentation error
    a. Check that the target object is an artery
    b. Check that the image does not contain any errors
    c. Re-trying segmentation
    d. If none of the above steps solves the error message you can contact IMAGEENS via the contacts listed in part 7 of this manual.
6. Region of interest analysis error
    a. Ensure that the data is consistent and uncorrupted, e.g. for a PC sequence, check that there is the same number for morphology and phase images)
    b. If the above step does not solve the error message you can contact IMAGEENS via the contacts listed in part 7 of this manual.
7. CSV export successful

b) Action pop-ups

The pop-ups requiring an action are divided into two categories according to the type of action to be performed. Some pop-ups will ask you to perform an action on the ArtFun+ plug-in window, others will ask you to interact directly with the pop-up.

Pop-up involving an action on ArtFun+:

1. How to make the bounding box for segmentation
2. How to make the initial circle manually
3. How to perform a segmentation correction manually
4. How to position the points for modeling the central aortic line
5. How to correct the points for modeling the central aortic line

Pop-up involving an action on the pop-up:

1. Request for automatic initial circle validation
2. Selection of the first frame for semi-automatic segmentation correction
3. Selection of the last frame for semi-automatic segmentation correction

Pop-ups 2 and 3 of this category ask you to select the first and last frame where you want to make a segmentation correction. ArtFun+ will then automatically correct the segmentation of the aorta between these frames.

5 Biomarker Calculation

5.1 Import series with Osirix or Horos

1. Import the cine (2D+t) PC or SSFP or 3D SSFP series that you want to examine to Osirix or Horos.
2. You can import DICOM files from CDs or other volumes or configure your local workstation as a DICOM network node to receive data directly from your local PACS network.
3. Open the series that you want to examine with Osirix or Horos by selecting the patient in the list and double click on the thumbnail. The series will appear in the Osirix/Horos 2D Viewer

4. Open ArtFun+: launch the plugin ArtFun+ via the plugin menu item or via the toolbar shortcut

5.2 Arterial Function Analysis

This part of the manual defines the manipulations that can be performed according to the types of images as well as the indices that can be drawn from the manipulations.

a) Aortic length on 3D SSFP processing

Quantification:

1. Use the point tool to create a point set.
2. Assign a label to the newly created ROI through the Segmentation label panel.
3. The centerline is automatically extracted and displayed in the Aortic length & 3D view panel, as well as the computed aortic length.

Indices	**Units**	**Descriptions**
Aortic length	Millimeters (mm)	Total length of the centerline

b) Cine (2D +t) PC processing

Flow visualization and correction

You can display the velocities on the viewer through the Show velocity layer icon **(a)**, and correct it with the Background Correction tool **(b)**. Switch back to morphology image with the Show magnitude layer icon **(c)**.

Quantification:

1. Use the segmentation tool to segment the arterial section.
2. Assign a label to the newly created ROI through the Segmentation label panel.
3. The area, flow and velocity curves are automatically extracted and displayed in the Arterial graphs and indicators panel, as well as related indicators.

4. If needed, compute transit time between two previously done ROIs by selecting both ROI colors in the Flow delay estimation panel.

Indices	**Units**	**Descriptions**
Max Area	Square centimeters (cm^2)	Maximal area of segmented section during the cardiac cycle
Min Area	Square centimeters (cm^2)	Minimal area of segmented section during the cardiac cycle
Variation	Percent (%)	Ratio of max-min area over min area. Also referred as Strain
Mean Diameter	Millimeters (mm)	Average diameter of the segmented section during the cardiac cycle (computed from area with a circular hypothesis)
Min Diameter	Millimeters (mm)	Minimal diameter of the segmented section during the cardiac cycle (computed from area with a circular hypothesis)
Max Diameter	Millimeters (mm)	Maximal diameter of the segmented section during the cardiac cycle (computed from area with a circular hypothesis)
Diameter Variation	Percent (%)	Ratio of max-min diameter over min diameter
Beginning of ejection	Milliseconds (ms)	Time instant where the cardiac ejection begins
Ejection peak	Milliseconds (ms)	Time instant where the cardiac ejection flow peak occurs
End of ejection	Milliseconds (ms)	Time instant where the cardiac ejection terminates
End of regurgitation	Milliseconds (ms)	Time instant where the cardiac flow regurgitation terminates
Acceleration volume	Milliliters (mL)	Blood volume sent by the heart from the beginning of ejection to the ejection peak

Ejection volume	Milliliters (mL)	Blood volume sent by the heart during the total ejection phase
Regurgitation volume	Milliliters (mL)	Blood volume going backward due to regurgitation
Net volume	Milliliters (mL)	Blood volume flowing through during the whole cardiac cycle
Regurgitation fraction	Percent (%)	Ratio of the regurgitation volume over the net volume.
Flow at ejection peak	Milliliters per seconds (mL/s)	Flow value recorded at the ejection peak
Ejection acceleration slope	Milliliters per seconds per milliseconds (mL/s/ms)	First derivative (or slope) of the flow curve between the ejection start and peak. Quantifies the acceleration of flow.
Ejection start positive/negative	Milliseconds (ms)	Time instant where the cardiac ejection begins considering positive/negative flow only
Ejection peak positive/negative	Milliseconds (ms)	Time instant where the cardiac ejection flow peak occurs considering positive/negative flow only
Ejection end positive/negative	Milliseconds (ms)	Time instant where the cardiac ejection ends considering positive/negative flow only
Ejection volume positive/negative	Milliliters (mL)	Blood volume flowing through during the total ejection phase considering positive/negative flow only
Net volume positive/negative	Milliliters (mL)	Blood volume flowing through during the whole cardiac cycle considering positive/negative flow only
Flow at ejection peak positive/negative	Milliliters per seconds (mL/s)	Flow value recorded at the ejection peak for positive/negative flow
Transit Time (Require 2 arterial section ROIs)	Milliseconds (ms)	Time delay for the pulse wave to go from first arterial section to second one

c) Cine (2D+t) SSFP

Quantification

1. Use the segmentation tool to segment arterial section.
2. Assign a label to the newly created ROI through the Segmentation label panel.
3. The area curve is automatically extracted and displayed in the Arterial graphs and indicators panel, as well as related indicators.

Indices	Units	Descriptions
Max Area	Square centimeters (cm^2)	Maximal area of segmented section during the cardiac cycle
Min Area	Square centimeters (cm^2)	Minimal area of segmented section during the cardiac cycle
Variation	Percent (%)	Ratio of max-min area over min area. Also referred as Strain
Mean Diameter	Millimeters (mm)	Average diameter of the segmented section during the cardiac cycle (computed from area with a circular hypothesis)
Min Diameter	Millimeters (mm)	Minimal diameter of the segmented section during the cardiac cycle (computed from area with a circular hypothesis)
Max Diameter	Millimeters (mm)	Maximal diameter of the segmented section during the cardiac cycle (computed from area with a circular hypothesis)
Diameter Var	Percent (%)	Ratio of max-min diameter over min diameter

5.3 Stifness quantification

Changes in aortic stiffness have a high physiopathological relevance as they can lead to increases in the aortic pulse pressure [2,3] and the cardiac pressure afterload, which can cause left ventricular hypertrophy [4]. Arterial stiffness is recognized as a major risk factor in coronary heart disease [5,6], and is considered as an independent predictor of cardiovascular mortality [7,8,9,10,11]. It is therefore increasingly used in clinical practice [12]. Distensibility and pulse wave velocity (PWV) are commonly used to characterize the arterial stiffness [13,14,15,16,17]. The distensibility describes the ability of the artery to expand during systole, and is defined as the relative change in the cross-sectional area of the

artery (strain) divided by the local pulse pressure. The PWV is the propagation speed of the pulse wave along the artery, and is calculated as the ratio between the distance separating two locations and the transit time needed for the wave to cover this distance.

Distensibility: local index for stiffness:

Combining the estimation of the deformability and the pulse pressure, a local index of distensibility in the arterial section can be derived.

The distensibility is computed as:

$$D = \frac{\Delta A}{\Delta P} = \frac{Strain}{Brachial/Carotid\ PP}$$

The distensibility is automatically calculated and provided in the report if user makes the pulse pressures available.

Pulse Wave Velocity: regional stiffness index

Combining the estimation of the transit time and the estimation of the length of the aortic arch, a regional index of Pulse Wave Velocity in the aortic arch can be derived.

PWV is computed as:

$$PWV = \frac{\Delta L}{\Delta T} = \frac{Aortic\ length}{Transit\ time}$$

6 ArtFun+ Shutdown

In order to close ArtFun, you must click on the cross at the top left of the user interface window.

Attention: make sure you save your work before closing the program. Any unsaved data will be lost when you close the program.

7 Ask for support

You have troubles using the plugins? You have encountered a bug? Mail us at support@imageens.com and we will help you troubleshoot your issues!

8 Explanation of label logos

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	**Name of the medical device**
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Version	**Version of the medical device**
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