

# ICARO: A Computer Aided Diagnosis Tool for the Quantification of Intracoronary and Intravenous Echocardiography

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## Abstract

*The detection of coronary stenosis and myocardial viability with myocardial contrast echocardiography (MCE) has been based on the visual interpretation of the perfusion region by medical experts. To have a purely objective diagnostic result has been developed ICARO.*

*ÍCARO makes a complete analysis of an intracoronary or intravenous echocardiography (MCE-ic or MCE-iv) video sequence quantifying objectively the contrast uptake curves as well as the intensity levels on the myocardial wall among several other parameters.*

*Eighty cases have been analyzed using ÍCARO with more than 93 % of concordance between our software and the visual diagnostic of three cardiologists.*

*ÍCARO gives all the necessary tools to make a complete analysis of echocardiography video sequence with intracoronary and intravenous injection obtaining objective and quantified parameters, and making the diagnostic independent of the cardiologist.*

## 1. Introduction

The use of Myocardial Contrast Echocardiography (MCE) allows great results to diagnostic Acute myocardial infarction (AMI) and coronary stenosis. [1,2,3]. However, diagnostics have been based on the visual interpretation of the perfusion region by medical experts.

Nevertheless echocardiography images contain perfusion defects and image's artifacts. The detection of a perfusion defect means a correct diagnostic, however confuse both makes erroneous results. Only expert cardiologists can distinguish each one. This problem can be resolved with the use of quantification [4].

Using quantification, the influence of artifacts is reduced [5-7]. Also subjective diagnostics can be based on objective parameters placing the experience of the

cardiologist in a second plane. At the same time results can be reused and saved in databases to be consulted in future times.

To help specialists and to give objective results, ICARO has been developed, a computer Aided Diagnosis Tool for the Quantification of Intracoronary and Intravenous Echocardiography.

## 2. Methods

The researches of Wei and others proved that there is a relation between coronary flow and blood coronary volume that can be measured by MCE with intravenous injection of the contrast agent [5]. When microbubbles have been destroyed by the ultrasound pulse, the variation of the video intensity ("Video Intensity", VI) was fitted to an exponential function as

$$y = A \cdot (1 - e^{-\beta t}) \quad (1)$$

In an image  $y$  is the Video Intensity (VI) on an instant of pulsation  $t$ .  $A$  is a constant value called "plateau" that reflects the myocardial microcirculation state after a time  $t$  and  $\beta$  is the rate constant that determines the rate of rise of VI,  $\beta$  is proportional to the mean velocity of the microbubbles. These authors proved that the myocardial flow is proportional to myocardial flow is proportional to the mean velocity of the microbubbles. These authors proved that the myocardial flow is proportional to the product of "plateau" and the slope  $\beta$ .

On the basis of quantification in MCE proposed by Wei and others, it was decided to develop a software that allowed obtaining semiautomatically the main parameters of the study of intravenous myocardial perfusion and intracoronary myocardial perfusion (MCE-IV and MCE-IC) through segments and territories following the normalized model proposed by Cerqueira and others, that



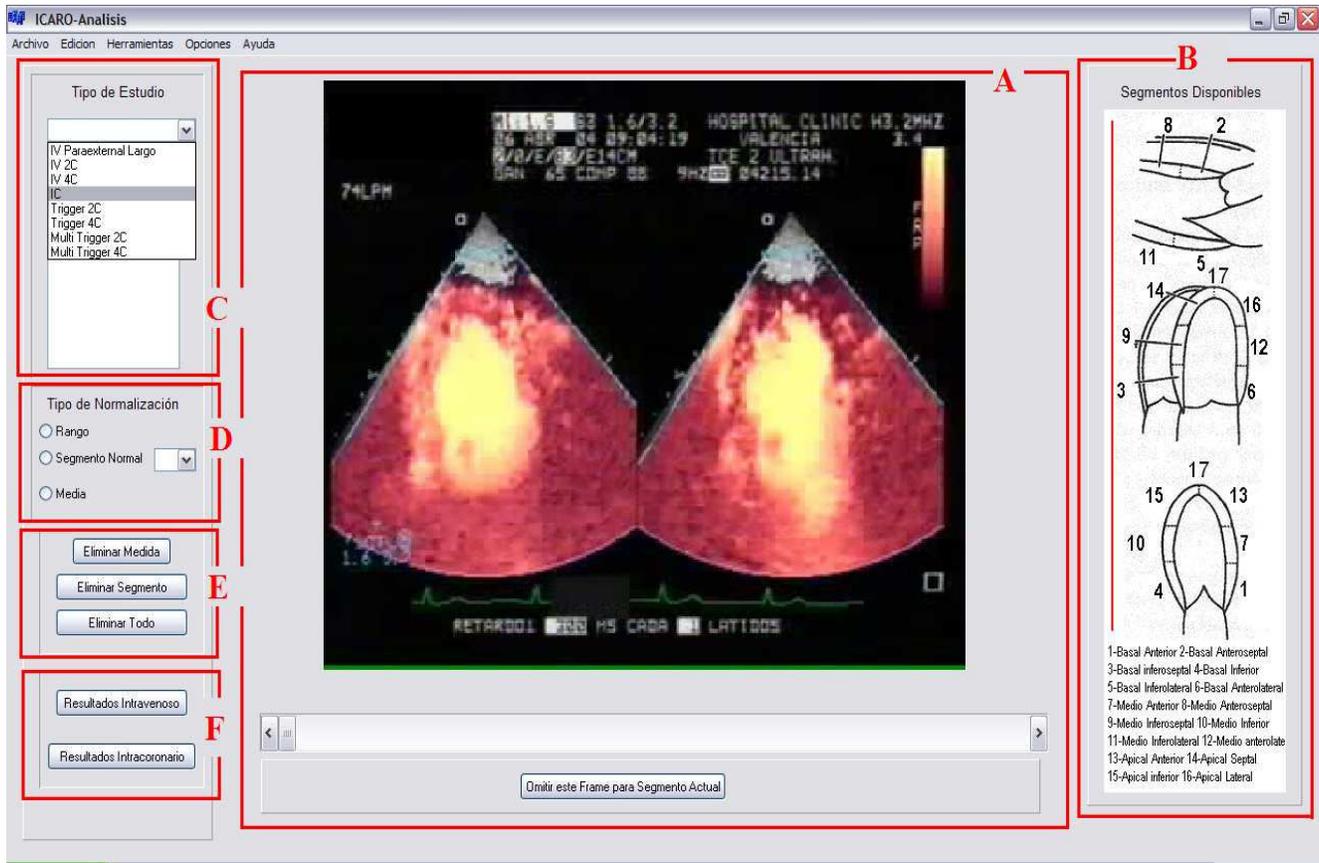


Figure 2 – ICARO’s Analysis Module

F: Results section. Once the study is finished the user will indicate ICARO clicking here to pass to the third module to show the results in new windows.

The third module is the result module. In this module, results are shown as contrast uptake for each heart segment for MCE-IV or multitrigger studies. As can be seen in figure 3 the main parameters of these curves (“plateau” maximum level and curve slope among others) are also presented. Here the user can compare segments and evaluate their quantified parameters.

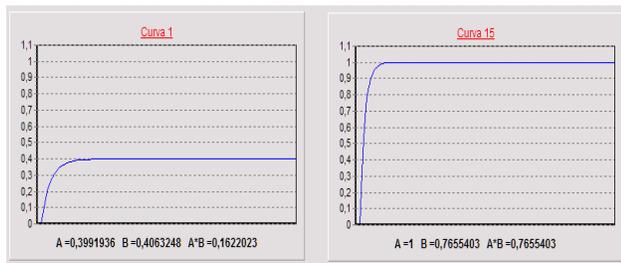


Figure 3 - Contrast uptake curves for segments 1 and 15 with the A, B and A\*B levels

For MCE-IC and triggered studies the results are represented as bar diagrams of contrast normalized intensity. As can be seen in figure 4 normal segment takes 1 and the other segments have proportional values.

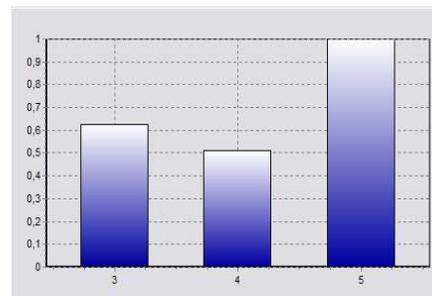


Figure 4 – Bar diagrams of video intensity for segments 3, 4 and 5

### 3. Results

ICARO has been tested by the Cardiology Department of the Hospital Clínico Universitario of Valencia, Spain. Eighty cases have been analyzed using ÍCARO with more than 93 % of concordance between our software and the visual diagnostic of three cardiologists. The 7% can be divided in 5% of false positives and 2% of false negatives. The time needed to make a complete study is about 3 minutes.

### 4. Discussion and conclusions

ICARO makes a complete analysis of an intracoronary or intravenous echocardiography (MCE-ic or MCE-iv) video sequence quantifying objectively the contrast uptake curves as well as the intensity levels on the myocardial wall among several other parameters. The software gives objective results, without experts influence. ICARO is an easy-to-use software that, with a short time for a study, gives results with a great percentage of concordance.

ICARO is being used daily at Hospital Clínico Universitario of Valencia as a helpful tool in perfusion evaluation with great success.

### Acknowledgements

This project has been partially subsidized by the action IIARC0/2004/249 of the Conselleria d'Empresa Universitat i Ciència de la Generalitat Valenciana.

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