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Institut Thématique Multi-Organismes
Technologies pour la santé

Laboratoire Traitement du Signal et de l'Image
LTSI

UNIVERSITÉ DE RENNES 1

Estimation à base de modèle du travail cardiaque dans la sténose aortique

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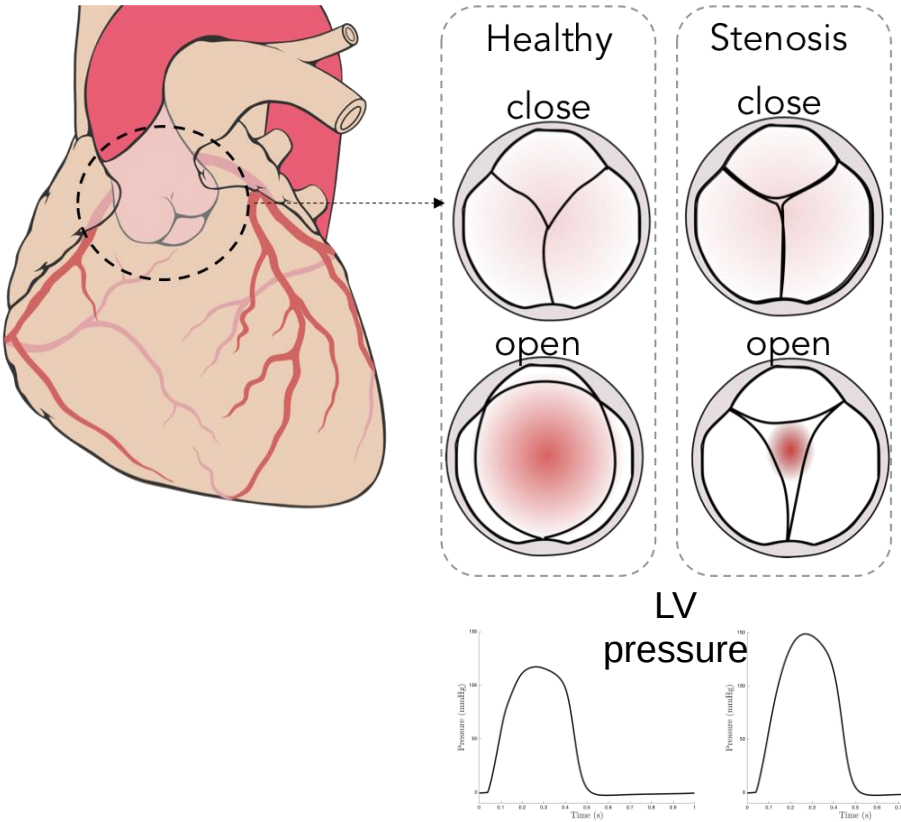
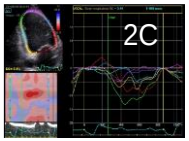
Aortic stenosis (AS)

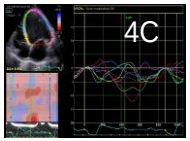


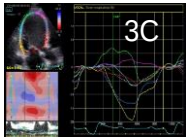
- AS Is characterised by a narrowing of the aortic valve opening.
- A left ventricle (LV) pressure overload is observed in several AS cases.
- AS Is usually accompanied by systolic and diastolic dysfunction.
- The characterisation of myocardial dysfunction is of primary importance.

Myocardial work

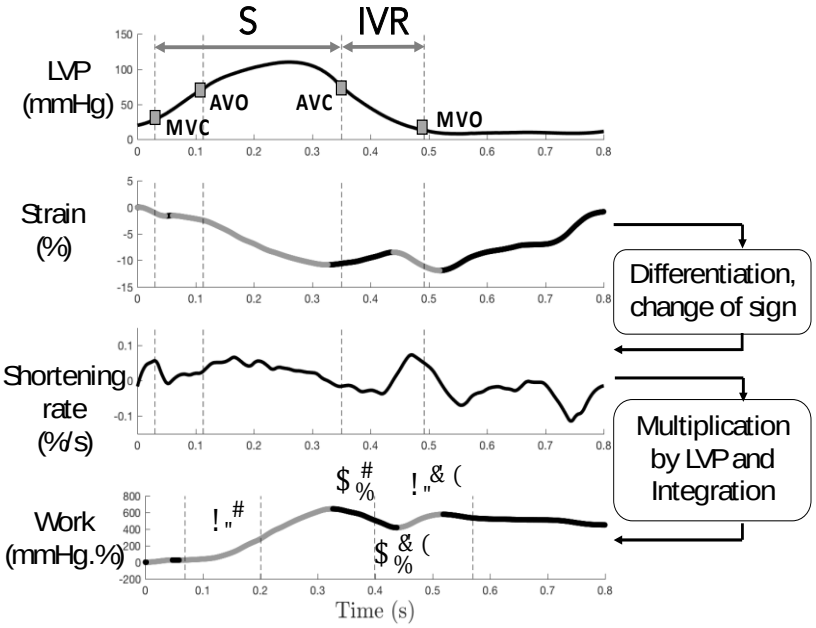
Echocardiography







Evaluation of regional cardiac deformation : STRAIN

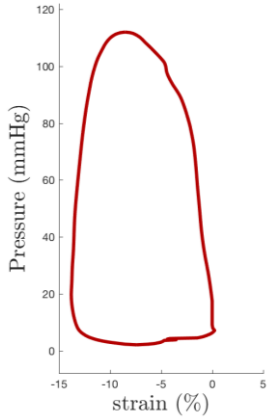


Global Constructive Work (GCW):
Positive work during S + Negative work during IVR

Global Wasted Work (GWW)
Positive work during IVR + Negative work during S

Global Work Efficiency (GWE)

$$GWE = \left(\frac{GCW}{GCW + GWW}\right)$$



Pressure strain loop (PSL)

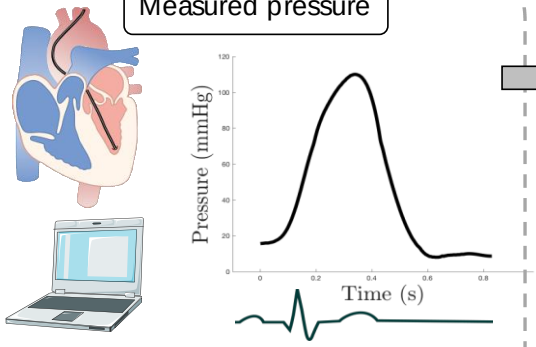
Objectives

- To propose a **noninvasive** approach to estimate **patient-specific LV pressure** curves in the case of **AS**.
- To evaluate and compare simulated and experimental **PSL** and **myocardial work indices** in AS patients.

Methodology

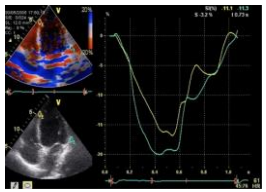
Clinical data

Measured pressure



ECG

Echocardiography



Leave-one-out approach

Repeated 4 times

3 Training patients | 4 patients | 1 Test patient

Step 1

Parameter Identification

$$\{X_{LV}^*, X_{art}^*\} = \underset{X_{LV}, X_{art}}{\operatorname{argmin}}\ J_{step1}(X)$$

$$J_{step1} = \epsilon_{LV} + \epsilon_{art,sys} + \epsilon_{art,dias}$$

$$J_{step2} = \epsilon_{art,sys} + \epsilon_{art,dias}$$

Mean ventricular parameters

$$\bar{X}_{LV}^* = \text{mean}(X_{LV}^*)$$

$$\epsilon_{art,sys} = \left| P_{ao,sys}^{exp} - P_{ao,sys}^{model} \right|$$

$$\epsilon_{art,dias} = \left| P_{ao,dias}^{exp} - P_{ao,dias}^{model} \right|$$

$$\epsilon_{LV} = \frac{1}{T_c} \sum_{t_e=0}^{T_c-1} \left| P_{LV}^{exp}(t_e) - P_{LV}^{model}(t_e) \right|$$

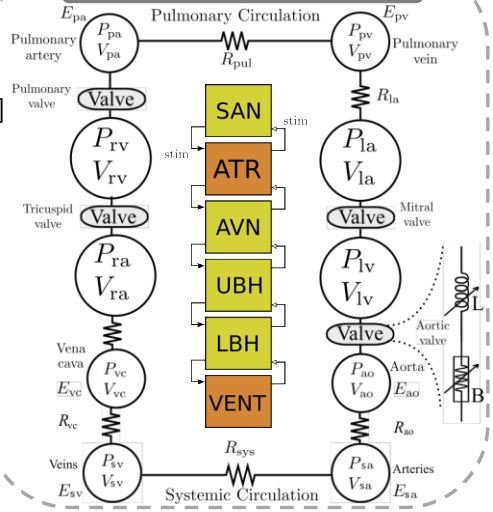
Step 2

Parameter identification

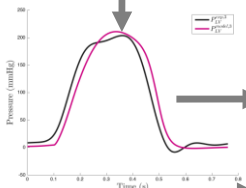
$$\{X_{art}^*\} = \underset{X_{art}}{\operatorname{argmin}}\ J_{step2}(\bar{X}_{LV}^*, X_{art})$$

P_{LV}^{model}

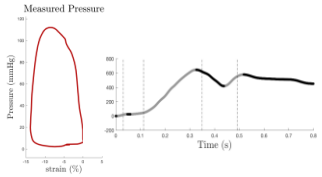
CVS model



Patient-specific simulated LV pressure

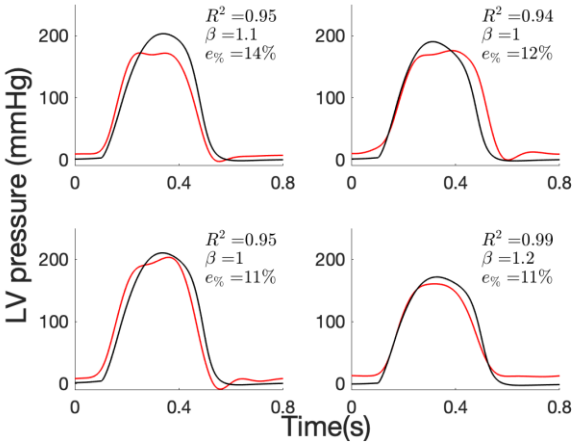


PSL and myocardial work



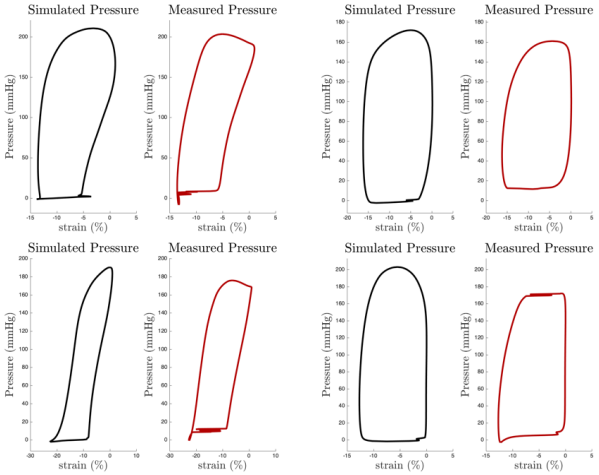
Results

LV pressure



RMSE = 20.34 ± 5.34

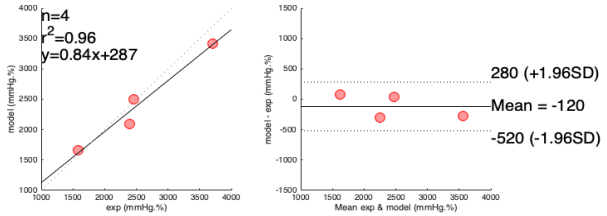
PSL



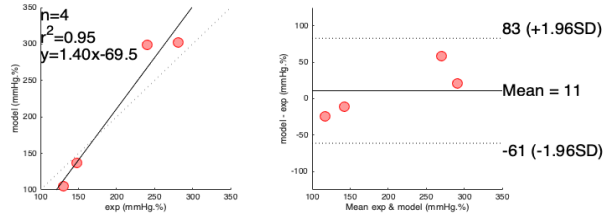
$Area_{exp}$ = 1965.6 ± 206.77 cm²

$Area_{sim}$ = 2206.4 ± 289.64 cm²

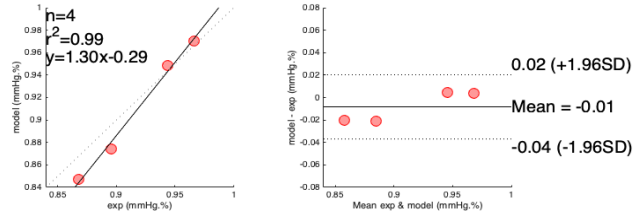
GCW



GWW



GWE



Conclusions

- We propose a parameter identification procedure, applied to an integrated CVS model, able to improve the reproduction of LV pressure specifically to each AS patient, by non-invasive procedures.
- PSL area markers and myocardial work appear as a robust surrogate estimation and as promising tools to provide prognostic information in AS patients.
- We are working with a greater population of patients (12 patients).