CARDIOLOGIE TUNISIENNE

ARTICLE ORIGINAL

# Impact of systemic hypertension on right ventricular function

# Impact de l'hypertension artérielle sur le ventricule droit

Meriem Drissa, Sana Helali, Madiouni Meriem, Yosri Ben Hamida, Habiba Drissa

*Cardiology department of la rabta hospital*

## Résumé

**Objectif:** Évaluer l'impact de l'hypertension artérielle sur la fonction ventriculaire droite.
**Méthodes:** Nous avons inclus 60 patients atteints d'hypertension artérielle non contrôlée (groupe A) et 60 sujets sains témoins (groupe B). Les deux groupes inclus sont indemnes de diabète, de cardiopathies ischémiques, de valvulopathies Les 2 groupes étaient appariés selon l'âge et le sexe.
**Résultats**: Il existait ne augmentation significative de l'épaisseur pariétale, du diamètre de l'oreillette gauche, de l'indice de masse ventriculaire gauche dans le groupe A. La fraction d'éjection du ventricule gauche était comparable entre les deux groupes. Le diamètre diastolique du ventricule droit (VD), la fraction d'éjection du VD , l'excursion systolique tricuspide du plan annulaire (TAPSE) et la variation de la fraction de raccourcissement de surface du VD étaient comparables entre les 2 groupes. La vitesse systolique S 'mesurée au niveau l'anneau tricuspide et le strain longitudinal global étaient significativement plus bas chez les patients hypertendus (9 ± 2 cm versus 14 ± 1 cm / s, p <0,01) et (-12 ± 2,6% versus - 20,1 ±0.2% p <0,01) reflétant un dysfonctionnement systolique infra clinique du VD. De plus, le pic de vélocité précoce (Ea) au niveau de l'anneau tricuspide était significativement plus bas dans le groupe A (7,9 ± 1,9 cm / s vs -13,1 ± 2,1, p <0,01) avec comme conséquence un rapport moindre Ea / Aa chez les patients hypertendus.
**Conclusion** : Notre étude a révélé une dysfonction systolique et diastolique du VD chez les patients hypertendus non contrôlés . Le doppler tissulaire et le strain rate ont permis une la détection de ces anomalies à un stade infra clinique.

Mots-clés
Hypertension artérielle, ventricule droit , échocardiographie, strain

## Summary

**Purpose:** To evaluate the impact of arterial hypertension on right ventricular function
**Methods:** We included 60 patients with uncontrolled hypertension without any associated pathology (group A ) and 60 healthy subjects control (group B). Subjects included in both groups were free from diabetes, valvular disease and ischemic heart disease. The 2 groups have a comparable average age and sex ratio.
**Results:** There was a significant increase in parietal thickness, left atrium diameter, left ventricular mass index in group A . The left ejection fraction was comparable between two groups. The diastolic diameter of the RV, the ejection fraction of the RV, the tricuspid annular plane systolic excursion (TAPSE) and the fractional area change were comparable between the 2 groups. The systolic velocity S' measured at the level of the annulus tricuspid and the global longitudinal strain rate were significantly lower in hypertensive patients(9 ±2 cm versus 14±1 cm/s ,p<0.01 ) and ( −12. ± 2.6 % versus − 20.1 ± 2 % p<0.01)reflecting subclinical RD systolic dysfunction. In addition, the early (Ea) peak velocity at the tricuspid annulus was significantly lower in group A (7.9± 1.9 cm/s versus . -13.1± 2.1, p<0.01 with a consequence lower Ea /Aa suggestion a RV relaxation disorder
**Conclusion** : Our study revealed a RV dysfunction in uncontrolled hypertension patients, Doppler tissue and 2D strain were very powerful in detection of RV abnormalities at an early subclinical stage

Keywords
Hypertension, right ventricle, echocardiography, strain

*Correspondance Mariem Drissa*
*Cardiology department of la rabta hospital*
*Mariemdrissa@yahoo.fr*

## INTRODUCTION

Left ventricular structural and functional changes in patients with arterial hypertension are well established. However, the influence of arterial hypertension on right ventricular (RV) remodeling is still being investigated. The aim of the current study was to determinate the RV systolic and diastolic function in uncontrolled hypertensive patients and compare these echocardiographic findings to the results of control subjects.

## METHODS

We conducted a prospective study in la Rabta hospital department between 2015-2016.
Sixty uncontrolled hypertensive patients (group A) were compared to age and gender matched 60 healthy control subjects (group B).
Group A patients has hypertension since 4 years, hypertension was uncontrolled under triple therapy because of poor treatment adherence.Otherwise patients were freedom from any signs of right or of left heart failure.
Patients with other causes of left ventricle (LV) hypertrophy, myocardial disease, ischemic heart disease, valvular heart disease, or pulmonary diseases were excluded. All subjects had echocardiography performed with the use of a VIVID 8.
Patients were explored by conventional echocardiography coupled to tissue Doppler and 2D strain.
Several parameters have been collected for the two groups and compared :Left ventricle mass, septum thickness, LV ejection fraction, left atrium area, anatomic characteristics of RV (wall thickness, basal diameter),systolic function of RV was assessed by (fractional area changes, RV ejection fraction (RVEF), tricuspid annular plane systolic excursion (TAPSE)), systolic velocity S' using tissue doppler and global longitudinal strain rate(GLS),
Diastolic function was assessed by tricuspid flow with standard pulsed Doppler by measurements of early diastolic peak flow velocity (E), late diastolic peak flow velocity (A), and the ratio of early□to□late flow velocity peaks (E/A ratio) and by tissue doppler of right ventricular lateral at tricuspid annulus characterized by myocardial early (Ea) and atrial (Aa) peak velocities and ratio Ea/Aa ratio.

### Statistical tests

We calculated simple frequencies and relative frequencies (percentages) for qualitative variables, means, medians and standard deviations for quantitative variables.we used the chi-square test and the student test respectively for the comparison of two percentages and two averages, in all the statistical tests, the significance level was fixed at0.05

## RESULTS

General characteristics of the hypertensive and control groups were listed in Table1 Echocardiographic LV characteristics for both groups were reported in table 2. LV Septum wall thickness, LV mass index,left atrium area were increased in hypertensive group (1,3cm,220g/m2, 21cm2) versus (0.8cm,125 g/m2,14 cm2) in control group attesting a LV hypertrophy.LV ejection fraction was also comparable between the 2 groups.

**Table 1 :** General characteristics of our population

| | Group A | Group B | p |
|---|---|---|---|
| **Age** | 56 ±7 | 52 ±7 | NS |
| **Sex ratio(female)** | 0.8 | 0.8 | Ns |
| **BMI** | 23±1 | 20±4 | NS |
| **Diabete (mmol)** | 4.9 ± 0.5 | 4.4 ±0.6 | NS |
| **Systolic BP(mmhg)** | 150±4 | 117±2 | P<0.001 |
| **Diastolic BP( mmhg )** | 90 ±2 | 72±5 | P<0.001 |

BP :blood pressure

**Table2 :** Echocardiographic left ventricle characteristics for both groups

| | Group A | Group B | p |
|---|---|---|---|
| **LV septum thickness (cm)** | 1,3± 0.9 | 0.8±0.5 | <0,01 |
| **LV mass index (g/m2)** | 220 | 125 | <0.01 |
| **LV EF(%)** | 61 ± 3 | 64±1 | NS |
| **Left Atrium area cm²** | 21 ± 0,5 | 14 ±06 | <0.01 |

LV EF :left ventricule ejection fraction

Assessment of functional and anatomical characteristics of the right ventricle of both groups were reported in table 3.
Group A presented a RV wall thickness (5.4 mm versus 2.6mm in group B,p<0.01) while RV diameter were comparable in both groups.Concerning RV systolic function many parameters were assessed(table 3). Fractional area changes, RVEF and TAPSE were normal in hypertensive patients and comparable to control group.
Whereas peak S' velocity at tricuspid annulus was reduced (9 ±2 cm versus 14±1 cm/s(p< 0.01) (figure 1).GLS was also significantly altered in group A (−12. ± 2.6% versus − 20.1 ± 0.2 % p<0.01 (figure2). By using tissue doppler and strain rate we attested a subclinical systolic function of RV in asymptomatic hypertensive

patients. Diastolic function was also assessed using pulsed doppler which revealed a tricuspid E/A ratio<0.8 in 92% of hypertensive patients attesting probable relaxation disorder. A complement of exploration using tissue Doppler at annulus tricuspid showed a decreased in Ea (-7.9± 1.9 cm/s in hypertensive group vs. -13.1± 2.1 , p<0.01 in control) and with consequence a low Ea/Aa ratio in group A.confirming the relaxation disorder of RV

**Table 3 :** Echocardiographic characteristics of the right ventricle in both groups

| | Group A | GroupB | p |
|---|---|---|---|
| **RV wall thikness (mm)** | 5.4 | 2.6 | <0.01 |
| **RV Diametre (mm)** | 43 ±4 | 42 ± 0,2 | NS |
| **RV EF(%)** | 62±1.3 | 65 ±1.6 | NS |
| **Fraction area Change(RV)%** | 38 ±1 | 40 ±1 | NS |
| **TAPSE(mm)** | 18 ±1 | 20± 1.5 | NS |
| **Tricuspid annulus S' velocity cm/s)** | 9± 2 | 14± 1 | < 0.01 |
| **RVGLS(%)** | - 12 ± 2.6 | - 20 ±0.2 | <0.01 |
| **E/A tricuspid** | 0.9 ± 0.2 | 1.3 ±0.3 | <0.01 |
| **Ea Tricuspid annulus(cm/s)** | -7.9± 1.9 | 13.1± 2.1 | <0.01 |
| **Ea/Aa tricuspid** | 0.8 ±0.1 | 1.32±03 | <0.01 |

RV: right ventricle , RVEF: right ventricle ejection fraction, T APSE: tricuspid annular plane systolic excursion, GLS :global longitudinal strain

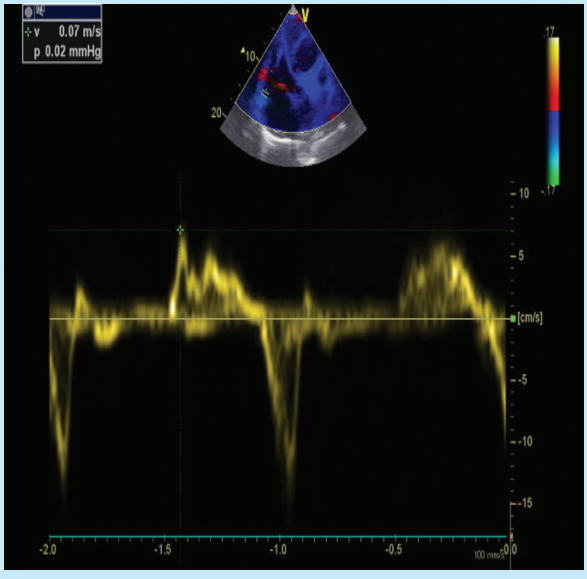


**Figure 1 :** Tricuspid annulus S' velocity cm/s reduced in hypertensive patients group

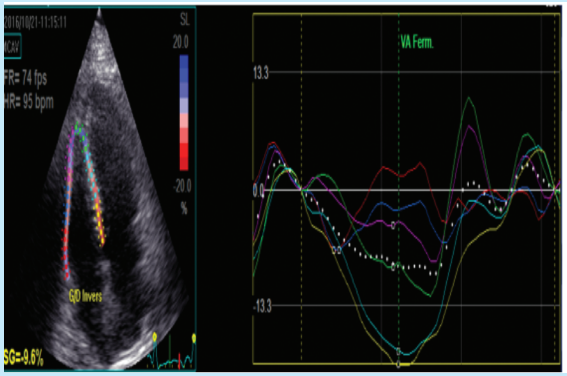


**Figure2 :** a reduced RV GLS ( %) in hypertensive group
RV GLS :right ventricular global longitudinal strain

## DISCUSSION

Systemic hypertension induces a progressive increase of left ventricular (LV) mass with consequent LV hypertrophy (LVH) and impairment of diastolic and systolic LV function.[1,2].In our study hypertrophy and increased mass index of LV was reported in hypertensive group us a consequence of uncontrolled blood pressure. But ejection fraction was still preserved.

Influence of arterial hypertension on LV ventricle is well established. However, the effect on right ventricular (RV) remodeling is still being investigated [1]

.The evaluation of the RV structure in the clinical practice considers the assessment of RV wall thickness, which was already confirmed as an important predictor of morbidity and- mortality in the global population free of cardiovascular disease.[3].Previous investigations have shown that RV wall thickness is increased in patients with arterial hypertension[4-7]

We reported the same results in our study since a thickness of RV wall was found in hypertensive patients(5.4 mm versus 2.6 mm in control group. This adaptive mechanism impacted pulmonary circulation and provoked RV remodeling. Many mechanisms were involved in RV hypertrophy in systemic hypertension including overstimulation of the sympathetic system and the renin–angiotensin aldosterone system could be responsible for increased pulmonary arteriolar resistance and furthermore for RV hypertrophy [8]and the mechanical interaction between the 2 ventricles through interventricular septum which represent a structure that determines systolic functions of both the ventricles and it is considered as "the lion of the RV function.")[9].

Ventricular interdependence refers to the fact that the shape, size, and compliance of one ventricle may influence the shape, size, or pressures in the other ventricle; an essential concept for understanding the

pathology of right ventricle (RV) dysfunction.[10].The impairment of RV systolic function in arterial hypertension could be related with increased RV filling pressures, RV hypertrophy, and ventricular interdependence [ 11].

To evaluate RV systolic function we used different techniques and parameters we did not find any significant difference in RVEF between the hypertensive and the healthy groups.Todiere[12] in his study including 25 hypertensive patients and 24 controls reported similar results. Fractional area change (FAC) another parameter of RV systolic function, remains within the normal range for a long time and deteriorates last in the cascade [13]. Similar results were observed in our study since FAC was normal in our hypertensive patients.

TAPSE, a good estimate of RV global systolic function [14], was not reduced in our hypertensive group. Others studies agreed with our results [15,16].

However some authors found the deterioration of RV systolic function by the usage of tissue doppler to determinate a reduced of systolic peak velocity of the RV wall at the level of tricuspid valve[17,18 ]attesting the role of this technique in detecting myocardial functional changes in specific, diseased regions, even when the function of other segments and the entire chamber is still normal. In fact in our study we reported that peak S' at annulus tricuspid was reduced 9 ±1 cm versus 14±1 cm/s, (p< 0.01) suggesting a latent subclinical dysfunction of RV even the absence of ejection fraction impairment.

The number of studies that investigated RV strain in the patients with arterial hypertension is limited. Only recently have the studies that investigate RV mechanics in hypertensive patients appeared. They have shown significant deterioration of RV longitudinal deformation[[16,19]and revealed the association between RV longitudinal strain and functional capacity in hypertensive patients[6,20**]**.Our results were in according with those reported by these previous studies GLS is a promising technique to quantify the regional RV ventricular function was a sensitive parameter of RV function that could detect changes at subclinical levels. (13).In our study by using 2Dstrain we unmasked a latent RV dysfunction in asymptomatic hypertensive patients who had a normal parameters of RV systolic function such us RVEF,TAPSE and FAC. Hanboly[17] showed not only that RV GLS was reduced in hypertensive patients, but also that apical and mid segments of RV free wall were more deteriorated than the basal RV segment in the hypertensive subjects. Our patients were only evaluated by global longitudinal strain rate since we had excluded any patients with associated ischemic disease. Unlike the uncertainty that exists in the relationship between arterial hypertension and RV systolic function, almost all investigators agree that arterial hypertension impacts RV diastolic function.[12].

Both ventricles are structurally and functionally interdependent on each other, so

The deterioration of RV diastolic function might possibly be explained by increased stiffness of the RV caused by hypertrophy, retrograde transmission of increased LV filling pressure to the pulmonary circulation and ultimately to the RV, negative influence of biohumoral systems [13].

The overall prevalence of R diastolic dysfunction was higher than that of right ventricle systolic dysfunction [17].

The evaluation of RV diastolic function was mainly performed by pulsed doppler.In fact diastolic measurements were altered at the level of RV lateral tricuspid annulus in.Tumuklu **[21]** echocardiographic study including 35 patients with arterial hypertension and 30 age and sex- adjusted control subjects, Hanboly(17) also found a tricuspid E/A ratio <0.8 in 60% hypertensive patient suggesting a diastolic dysfunction of RV. Similar results were reported in our study when 92% of hypertensive patients presented E/A<0.8 attesting a probable RV relaxation disorder.

Tissue Doppler indices at tricuspid annulus adds information in assessment of diastolic RV function. In fact Cicala et al. [15] reported that tricuspid annular Ea/Aa ratio was predictor of RV diastolic dysfunction, of the same HANBOLY reported in his study a decreased tricuspid Ea/Aa ratio in hypertensive group 0.9 ± 0.3 vs. 1 1.3 ± 0.1 in the control groups, p < 0.001. This same ratio Ea/Aa was lower in our hypertensive patients attesting a relaxation disorder of RV.

### Limits of study

We selected a patients with uncontrolled hypertension. This can be a selection biais since uncontrolled hypertension patients developed more ventricular hypertrophy and with consequence more RV dysfunction then controlled or mid controlled hypertension patients.

-The small size of our population is the main limitation of our work, and other single or multi-center studies, including a larger number, will improve the validity of our results.

### Acknowledgments

II would like to thanks all my coauthors ho had participated to the elaboration of this manuscript.

### Conflicts of interests.

No conflicts of interests

## CONCLUSION

-Our study shows the presence of subclinical RV dysfunction in uncontrolled hypertensive patients, reflecting LV / RV interdependence and the contributory role of the interventricular septum in RV function

Tissue Doppler and 2D strain were very powerful tools in the early detection of these subclinical functional abnormalities.

Since RV function is an important parameter in cardiac disease a diagnostic of this dysfunction at an early stage incites to a better control of hypertension by using of drugs induce both blood pressure decrease and reduction of cardiac hypertrophy and thus avoiding RV impairment.

## REFERENCES


1. Vakili BA, Okin PM, Devereux RB. Prognostic implications of left ventricular hypertrophy. Am Heart J 2001;141:334 41. 3.
2. Bella JN, Palmieri V, Roman MJ, et al. Mitral ratio of peak early to late diastolic filling velocity as a predictor of mortality in middle aged and elderly adults: The Strong Heart Study. Circulation 2002;105:1928 33.
3. Kawut SM, Barr RG, Lima JA, et al. Right ventricular structure is associated with the risk of heart failure and cardiovascular death: the Multi- Ethnic Study of Atherosclerosis (MESA) – right ventricle study. Circulation. 2012;126:1681-1688.
4. Cuspidi C, Sala C, Muiesan ML,, et al. Right ventricular hypertrophy in systemic hypertension: an updated review of clinical studies. J Hypertens. 2013;31:858-865.
5. Cuspidi C, Negri F, Giudici V, et al. Prevalence and clinical correlates of right ventricular hypertrophy in essential hypertension. J Hypertens. 2009;27:854-860.
6. Tadic M, Cuspidi C, Suzic-Lazic J, et al. Is there a relationship between right- ventricular and right atrial mechanics and functional capacity in hypertensive patients? J Hypertens. -2014;32:929-937
7. Ivanovic BA, Tadic MV, Celic VP. To dip or not to dip? The unique relationship between different blood pressure patterns and cardiac function and structure. J Hum Hypertens. 2013;27:62-7
8. Schermuly RT, Ghofrani HA, Wilkins MR, Grimminger F. Mechanisms of disease: pulmonary arterial hypertension. Nat Rev Cardiol. 2011;8:443-455
9. Buckberg GD, Hoffman JI, Coghlan HC.Ventricular structure- function relations in health and disease: Part I. The normal heart. Eur J Cardiothorac Surg. 2015;47:587-601. .
10. [ -Clyne CA, Alpert JS, Benotti JR. Interdependence of the left and right ventricles in health and disease. Am Heart J 1989;117:1366 73.
11. Ferlintz J. Right ventricular performance in essential hypertension. Circulation. 1980;61:156-162.
12. Todiere G, Neglia D, Ghione S, et al. Right ventricular remodelling in systemic hypertension: a cardiac MRI study. Heart. 2011;97:1257-1261.
13. Tadic M1, Cuspidi C2, Bombelli M. Right heart remodeling induced by arterial hypertension: Could strain assessment be helpful J Clin Hypertens (Greenwich). 2018 Feb;20(2):400-407. doi: 10.1111/jch.13186. Epub 2018 Jan 25.
14. Kaul S, Tei C, Hopkins JM, Shah PM. Assessment of right ventricular function using two dimensional echocardiography. Am Heart J 1984; 128: 301–307
15. Cicala S, Galderisi M, Caso P, et al. Right ventricular diastolic dysfunction in arterial systemic hypertension: analysis by pulsed tissue Doppler. Eur J Echocardiogr. 2002;3:135-142.
16. Pedrinelli R, Canale ML, Giannini C. Abnormal right ventricular mechanics in early systemic hypertension: a two- dimensional strain imaging study. Eur J Echocardiogr. 2010;11:738-742
17. Hanboly NH. Right ventricle morphology and function in systemic hypertension. Nig J Cardiol. 2016;13:11-17.
18. Gregori M, Tocci G, Giammarioli B, et al.. Abnormal regulation of renin angiotensin aldosterone system is associated with right ventriculardysfunction in hypertension. Can J Cardiol. 2014;30:188-194.
19. Tadic M, Cuspidi C, Pencic B, Relationship between right ventricular remodeling and heart rate variability in arterial hypertension. J Hypertens. 2015;33:1090-1097
20. Tadic M, Ivanovic B. Why is functional capacity decreased in hypertensive patients? From mechanisms to clinical studies. J Cardiovasc Med (Hagerstown). 2014;15:447-455. 14
21. Tumuklu MM, Erkorkmaz U, Ocal A. The impact of hypertension and hypertension- related left ventricle hypertrophy on right ventricle function. Echocardiography. 2007;24:374-