Hội Tim Mạch Học Việt Nam
Vietnam National Heart Association

Tạp chí

Tim Mạch Học Việt Nam

JOURNAL OF VIETNAMESE CARDIOLOGY

(Xuất bản định kỳ 3 tháng 1 lần)

(Published quarterly)

Issue 103E (December, 2022)

JOURNAL OF VIETNAMESE CARDIOLOGY

OFFICE OF VIETNAM NATIONAL HEART AASSOCIATION
C Building - Bach Mai Hospital - 78 Giai Phong Street - Dong Da District - Hanoi - Vietnam
Telephone: +84.24.3868.8488 Fax: +84.24.3868.8488
Email: tapchi@vnha.org.vn Website: https://jvc.vnha.org.vn/

Publishing License No.: 472/GP-BTTTT issued on: 22-7-2021

TABLE OF CONTENTS

Demographic-clinical characteristics of patients in cardiology consultation: Results from the Hung Vuong Hospital Registry

Piter Martínez Benítez✉, Yanitsy Rodríguez Chipi , My Thi Ha Chu

Hung Vuong General Hospital

ABSTRACT

Background: Non-communicable diseases are one of the leading causes of death in Vietnam. This situation in North Vietnam has not been well documented for the last 10 years. **Objective:** to characterize patients admitted to the cardiology outpatient consultation of Hung Vuong Hospital in terms of key demographic variables, prevalence of common risk factors and cardiovascular diseases, and the interaction between them. **Method:** the research was a cross-sectional descriptive study of 2,054 patients from October 2021 to April 2022. **Results:** The mean age of the patients was 56.36 years, with a predominance of females (55.89%). The main cardiovascular risk factors were arterial hypertension (high prevalence, 57.16%), dyslipidemia (33.3%), and smoking (20.84%). The main diagnoses at admission were high blood pressure, coronary heart disease, heart failure, valvular disease, and arrhythmia with 28.04%, 15.48%, 10.13%, 5.65%, and 5.11%, respectively. A high proportion of patients with hypertension did not have adequate control of it (62.27%). Only 11.5 % of the patients had optimal levels of LDL-C corresponding to cardiovascular risk. The prevalence of heart failure with preserved ejection fraction was high (54.33%), which occurred in a higher percentage in 59.85% compared to men 44.74% (p=0,002). **Conclusions:** The levels in terms of prevalence, knowledge, and control of arterial hypertension are worrying. Smoking prevalence was also high. Most of the patients with a history of coronary artery disease had elevated LDL-C levels. Heart failure with preserved ejection fraction predominated mainly in women.

Keywords: Cardiovascular disease, risk factors, prevalence.

BACKGROUND

Cardiovascular disease, listed as the underlying cause of death, accounted for 874,613 deaths in the United States in 2019. Cardiovascular disease (CVD) claim more lives each year in the United States than all forms of Cancer and Chronic Lower Respiratory Disease combined. Between 2015 and 2018, 126.9 million adults had some form of CVD. Between 2017 and 2018, direct and indirect costs of total CVD were $378.0 billion ($226.2. billion in

Correspondence to: Dr. Piter Martínez Benítez. Department of Cardiology, Hung Vuong General Hospital, Phu Tho, Vietnam. E-mail: martinezbcard@gmail.com

direct costs and $151.8 billion in lost productivity/ mortality). [1]

In Vietnam, out of 520,000 total deaths, non-communicable diseases were estimated to account for 73%. CVD was estimated to occupy 33 % of all deaths and stroke was found to be the leading cause of death among them. In addition, the morbidity and mortality of CVD in hospital settings were 9.0 % and 18.6 % respectively. [2]. At the sixth National Scientific Conference in Hanoi on November 21, the Vietnam Medicine Association and the Ministry of Health raised the fact that non-communicable diseases (NCDs) are now a leading cause of death in Vietnam. [2]

CVD are influenced by a wide variety of risk factors such as tobacco use, excessive alcohol consumption, unhealthy diet, physical inactivity, overweight and obesity, elevated blood glucose, and abnormal blood lipids. The combination of a reduction of risk factors in the general population, primary prevention in high-risk groups, and intensive treatment in secondary prevention was claimed to be the best strategy to reduce CVD premature mortality. [3]

Consultations with specialists are essential for safe and high-quality care for all patients. Cardiology consultations, due to a progressive increase in cardiology comorbidities, are becoming more common in hospitals before any type of treatment. Not only do consultations play an important role in the diagnosis and treatment of a heart condition, but they are also crucial in educating the patient on lifestyle changes required to prevent the condition from worsening or to hasten the recovery process. [4]

The CVD situation in Vietnam has not been well-documented, and this data is important for Vietnamese health organizers in designing effective intervention strategies.

Therefore, the objective of this study is characterized patients admitted to the cardiology outpatient consultation of Hung Vuong Hospital in terms of key demographic variables, the prevalence of common risk factors and cardiovascular diseases, and the interaction between them. The findings of this study would be useful in low-income communities and contribute to the development of intervention and primary prevention strategies in the diagnosis and treatment of cardiovascular diseases in this community and Vietnam.

METHODS:

Study design: the research was a cross-sectional descriptive study to assess the characteristics and risk factors of patients admitted to the cardiology outpatient clinic of Hung Vuong Hospital (located in Chi Dam community, Doan Hung district, Phu Tho province, Viet Nam) from October 2021 to April 2022. A total of 2,054 consecutive patients were identified. All patients admitted to an outpatient cardiology consultation were included in the study. The informed consent of the participating patients was not necessary, due to the retrospective nature of the study; their data is not recorded in this manuscript.

The following parameters were analyzed: age, sex, main risk factors for cardiovascular disease: smoking (smoker and ex-smoker), diabetes mellitus, arterial hypertension, chronic kidney disease, peripheral arterial disease, coronary artery disease, and dyslipidemia. Admission diagnoses included hypertension, heart failure, coronary heart disease, arrhythmia, syncope, hypertrophic cardiomyopathy, valvular heart disease, pericarditis, aortic dissection, congenital heart disease, pulmonary embolism, and cardiac tumor. The classification of hypertension was considered by the 2021 European Society of Hypertension

practice guidelines consensus document for office and out-of-office blood pressure (BP) measurement. [5] Dyslipidemia was considered according to the low-density lipoprotein cholesterol (LDL-C) levels shown in the guide for the management of dyslipidemias: lipid modification to reduce cardiovascular risk 2019. [6] Heart failure was classified following the heart failure (HF) classification algorithm according to left ventricular ejection fraction (LVEF) of the 2022 guideline for the management of heart failure. [7]

The investigation was under the ethical principles set out in the Declaration of Helsinki.

Data collection: A database that included the record of consecutive patients seen in the cardiology outpatient consultation of the Hung Vuong hospital and clinical history books were used to collect relevant information from the patients.

Data analysis: The information was processed by the statistical packet IBM SPSS version 22.0. Continuous variables had a normal distribution according to the Kolmogorov-Smirnov test; they were presented as mean ± standard deviation. Categorical variables were described as counts (percentages) and compared by Pearson chi-square test (Pearson χ^2 test) or Fisher's exact test appropriately. A p-value <0.05 with a 95 % confidence interval was regarded as statistically significant.

RESULTS

A total of 2,054 patients were admitted, with a mean age of 56.36 years, predominantly female (55.89 %). The age group with the highest proportion of patients in both genders was 60 to 69 years old with 27.7 % and 24.82 %, respectively (Table 1).

Table 1. Baseline clinical characteristics (n=2,054)

Age groups (years)	Gender					
	Male (906)		Female (1,148)		Total (2,054)	
	n	%	n	%	n	%
1 to 18	35	3.86	29	2.53	64	3.12
19 to 29	39	4.30	32	2.79	71	3.46
30 to 39	82	9.05	107	9.32	189	9.20
40 to 49	135	14.90	163	14.20	298	14.5
50 to 59	201	22.19	264	22.99	465	22.64
60 to 69	251	27.70	285	24.82	536	26.10
70 to 79	112	12.36	184	16.03	296	14.41
80 to 89	45	4.97	73	6.36	118	5.74
90 and over	6	0.66	11	0.96	17	0.83
Total	906	44.11	1,148	55.89	2,054	100

The patients were distributed according to the main cardiovascular risk factors and lifestyle habits by gender. A high prevalence of arterial hypertension (57.16 %) was observed, followed by dyslipidemia (33.3 %). The prevalence of smoking was 20.84 % (including smoker and ex-smoker patients); this proportion in men was significantly higher than in women with statistical significance (p<0.001). The prevalence of coronary artery disease and diabetes mellitus was 9.88 % and 7.98 %, respectively. All cardiovascular risk factors were present more frequently in males, except for dyslipidemia, numerically higher in women but not statistically significant (Table 2).

Table 2. Cardiovascular risk factors and lifestyle habits by gender

	Gender						
Risk factor	**Male (n=906)**		**Female (n=1,148)**		**Total (n=2,054)**		
	n	**%**	**n**	**%**	**n**	**%**	**P**
Smoker	254	28.04	8	0.7	262	12.76	**<0.001**
Ex-smoker	160	17.66	6	0.52	166	8.08	**<0,001**
Diabetes Mellitus	89	9.82	75	6.53	164	7.98	**0.006**
Arterial Hypertension	571	63.02	603	52.53	1174	57.16	**<0.001**
Chronic kidney disease	37	4.08	12	1.05	49	2.39	**<0.001**
Peripheral artery disease	7	0.77	2	0.17	9	0.44	0.049
Coronary artery disease	109	12.03	94	8.19	203	9.88	**0.004**
Dyslipidemia	301	33.22	383	33.4	684	33.3	0.947

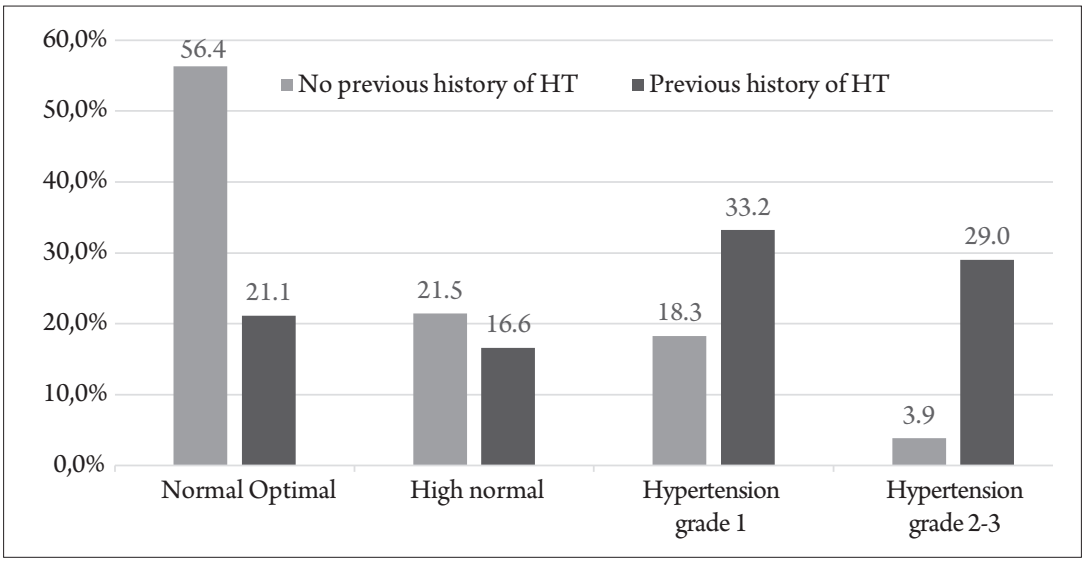
Main diagnoses at admission were arterial hypertension, coronary heart disease, heart failure, valvular heart disease and arrhythmia with 28.04 %, 15.48 %, 10.13 %, 5.65 %, 5.11 % respectively. A low prevalence of chronic kidney disease and peripheral arterial disease was observed. After stratification by sex, men were found to have a higher proportion of coronary heart disease than women, conversely, women had a higher proportion of heart failure than men (Table 3).

Table 3. Diagnosis at admission

Diagnosis	**Male (n=906)**		**Female(n=1,148)**		**Total (2,054)**	
	n	**%**	**n**	**%**	**n**	**%**
Arterial Hypertension	254	28.03	322	28.05	576	28.04
Heart Failure	76	8.39	132	11.5	208	10.13

Coronary heart disease	181	19.98	137	11.93	318	15.48
Arrhythmia	39	4.30	66	5.75	105	5.11
Stroke	19	2.1	11	0.96	30	1.46
Syncope	0	0.0	1	0.09	1	0.04
Hypertrophy Myocardiopathy	7	0.77	3	0.26	10	0.49
Valvular Heart Disease	30	3.31	76	6.62	116	5.65
Pericarditis	0	0.0	1	0.09	16	0.78
Aortic Dissection	2	0.22	2	0.17	4	0.19
Congenital Heart Disease	8	0.88	17	1.48	25	1.22
Pulmonary Embolism	0	0.0	3	0.26	3	0.15
Cardiac Tumor	0	0.0	1	0.09	1	0.05

Graph 1 recorded the blood pressure obtained in the outpatient cardiology consultation in patients with and without a history of arterial hypertension. A total of 195 patients (22.16 %) without a history of arterial hypertension had elevated blood pressure levels. A high proportion of patients with the disease did not have adequate control of it (62.27 %).



Graph 1. Blood pressure in patients with and without a history of arterial hypertension

Patients with a history of coronary artery disease and LDL-C were summarized in Table 4, finding that only 11.5 % of patients had optimal levels of LDL-C corresponding to cardiovascular risk.

Table 4: LDL-C and history of coronary artery disease

	History of coronary artery disease	
LDL-C Levels (mmol/L)	**n**	**%**
<1.4	9	11.5
1.4 to < 1.8	4	5.1
1.8 to < 2.6	18	23.1
2.6 to < 3.0	6	7.7
3.0 to < 4.6	39	50.0
≥ 4.6	2	2.6
Total	78	100

LDL-C: low-density lipoprotein cholesterol

Regarding patients with heart failure and gender, Table 5 showed a predominance of patients with heart failure with preserved ejection fraction (54.33%), which occurred in a higher percentage in women 59.5% compared to men 44.7% with statistical significance (p=0.002).

Table 5: Type of heart failure and gender

	Gender						
Type of HF	**Male (n=76)**		**Female (n=132)**		**Total (n=208)**		
	n	**%**	**n**	**%**	**n**	**%**	**p**
HFrEF	24	31.58	21	15.90	45	21.63	0,208
HFimpEF	1	1.31	2	1.52	3	1.44	1.000
HFmrEF	17	22.37	30	22.73	47	22.60	0.267
HFpEF	34	44.74	79	59.85	113	54.33	**0.002**
Total	76	100	132	100	208	100	

Abbreviations: HF: heart failure, HFimpEF: heart failure with improved ejection fraction, HFmrEF: heart failure with mildly reduced ejection fraction, HFpEF: heart failure with preserved ejection fraction, HFrEF: heart failure with reduced ejection fraction.

DISCUSSION

Vietnam faces a double burden of disease. Although infectious diseases tend to decrease, the proportion of cases of non-communicable diseases is increasing. These data provide a comprehensive description of CVD patients referred to the cardiology outpatient consultation at Huong Vuong Hospital, Phu Tho Province. The results of this study show that the baseline clinical characteristics of the patients were similar to those reported by other studies in Vietnam. [2,3,8] Some significant differences were shown by the CLARIFY registry in Spain that described the baseline characteristics of the Spanish cohort compared to the Western European cohorts included in the registry, where the majority of participants were men (81% in Spain and 79 % in the rest of the sample). [9]

The rate of progression of atherosclerosis and

cardiovascular disease is influenced by cardiovascular risk factors, and hypertension prevalence in different countries differs dramatically. Using data from 2015 to 2018, 121.5 million (47.3 %) American adults had high blood pressure. [1] Studies on the prevalence of hypertension in Vietnam have reported various estimates. A report on the prevalence and risk factors of arterial hypertension in two mountainous communes in central Vietnam showed a prevalence of 47.3 % (319/675 people). [8] The estimate for the prevalence of hypertension in this report appeared to be much higher (57.16%) than estimates reported in other studies. [2,3] A systematic review and meta-analysis in Vietnam showed that the pooled estimate of hypertension prevalence measured from 10 studies published between 2005 and 2018 was 21.1 % and the pooled estimate from the 3 national survey studies was lower (18.4 %). [10]

Among non-Hispanic Asian adults aged 20 years and older between 2015 and 2018, 51.0 % of men and 42.1 % of women had hypertension, as did the current study. [1] Meiqari L. and colleagues in a 2019 Vietnamese meta-analysis showed that the pooled prevalence of hypertension was significantly higher among men than women (26.4 % vs. 16.6 %); [10] results similar to those of the present investigation.

The difference in prevalence observed between the present study and other studies could be due to social and cultural differences, changes in diet and lifestyle, and an increase in life expectations. As in other communes in Vietnam, this is an area with many socioeconomic difficulties in providing health services. In addition, people are not fully aware of the dangerous risks of high blood pressure and access to health services for its diagnosis and prevention is limited.

Hanoi National Hospital for Tropical Diseases evaluated dyslipidemia and cardiovascular diseases in Vietnamese people with human immunodeficiency virus (HIV) receiving antiretroviral therapy in 2016, the prevalence of dyslipidemia was 53.5 %. [11] Another investigation to determine the prevalence of dyslipidemia and its risk factors among adults in the rural area of Thai Binh, Vietnam, found a prevalence of 56.1 % in the study subjects; [12] these patterns were not consistent with the results of the present investigation, whose prevalence was 33.3%.

Worldwide, tobacco contributed to an estimated 8.09 million deaths in 2020. [1] At the time of the study, the prevalence of smoking was 20.84%, predominantly in men, 45% vs 1.22%, with statistical significance ($p<0.001$); similar results showed a report from central Vietnam in 2020, where the ratio of male smokers to female smokers in question was approximately 3:1. (53.9% vs. 17.2%, $p < 0.001$). [2] Findings from the Global Adult Tobacco Survey showed a prevalence of smoking of approximately 45 % in men and 1.1 % in women similar to the present study. [13]

Cardiovascular diseases are caused by disorders of the heart and blood vessels. They include coronary heart disease (heart attacks), cerebrovascular disease (stroke), high blood pressure (hypertension), peripheral arterial disease, rheumatic heart disease, congenital heart disease, and heart failure. [14] The main admission diagnosis recorded in the present study were high blood pressure followed by coronary artery disease and heart failure which does not match the 2019 statistics in the United States where coronary heart disease was the main diagnosis causing 41.3% of deaths attributable to CVD. followed by other CVDs (17.3%), cerebrovascular accidents 17.2%), arterial hypertension (11.7%), heart failure (9.9%), and diseases of the arteries (2.8%). [1]

Prabhakaran D. and colleagues studied the epidemiology of CVD in India and found that ischemic heart disease and stroke accounted for

the majority of CVD mortality (83%), followed by hypertensive heart disease, rheumatic heart disease, cardiomyopathy, and myocarditis, [15] which differs from this study where arterial hypertension prevailed as the main diagnosis.

Joseph P and colleagues estimated that the contribution of atrial fibrillation and atrial flutter to the overall burden of CVD in India was small. Furthermore, the proportional burden of mortality and morbidity attributable to other types of CVD, such as aortic aneurysms, peripheral vascular disease, and endocarditis, was also relatively small as was the present investigation. [16]

Taking into account that arterial hypertension had a high prevalence in the investigation, the blood pressure obtained in the outpatient consultation was recorded in patients with and without a history of arterial hypertension. A total of 195 patients (22.16%) without a history of hypertension had high blood pressure levels. Of significant concern is the fact that only 26% of the Vietnamese are aware of their hypertension status. This challenge is particularly relevant in rural areas where only 24% of hypertensive are aware of their high blood pressure in contrast to 38.4 % in urban areas. [17]

Researchers from NCD Risk Factor Collaboration (NCD-RisC) analyzed trends in hypertension prevalence and progress in treatment and control from 1990 to 2019 of 1201 population-representative studies with 104 million participants and showed that 27-34% of women and men in the high-income western and Asia-Pacific regions with hypertension were not aware of their condition. [18] The present investigation showed a higher percentage of patients who did not have adequate control of their hypertension (62.27%).

Numerous epidemiological studies, Mendelian randomization studies, and trials have consistently demonstrated a log-linear relationship between the absolute changes in plasma LDL-C and the risk of atherosclerosis cardiovascular disease (ASCVD). [19,20] Therefore, the effect of LDL-C on the risk of ASCVD appears to be determined by both the absolute magnitude and the total duration of exposure to LDL-C. Therefore, for patients at very high CV risk, whether in secondary prevention or primary prevention, LDL-C reduction of >50% from baseline and an LDL-C goal of <1.4 mmol/L (<55 mg/dL) are recommended. [6]

The present study showed elevated concentrations of LDL-C in patients with a history of coronary artery disease, finding that only 11.5% of these patients had optimal levels of LDL-C corresponding to cardiovascular risk. A JAMA Network report studied the association of coronary plaque with low-density lipoprotein cholesterol levels and cardiovascular disease event rates among 23,143 symptomatic adults and found that, overall, 10.5% had LDL-C levels less than 77 mg/dL; 34.4%, 77 to 112 mg/dL; 36.3%, 113-154 mg/dL; 14.7%, 155 to 189 mg/dL; and 4.1 %, at least 190 mg/dL. [20] This proportion was similar to patients with lower LDL-C levels in this report.

The importance of cardiovascular risk factor prevention remains unquestioned and should be applied at the general population level by promoting a healthy lifestyle by addressing unhealthy lifestyles and reducing elevated levels of cardiovascular risk factors such as LDL- C or blood pressure levels.

Heart failure is a complex clinical syndrome with symptoms and signs that result from any structural or functional impairment of ventricular filling or ejection of blood. Racial and ethnic disparities in death resulting from HF persist. HF with preserved ejection fraction represents at least 50% of the population with HF, and its prevalence is increasing. [7] The present study found a predominance of patients with heart failure with preserved ejection fraction (54.33%), similar to the statistics of the

current heart failure guide.

Single center retrospective studies have reported a prevalence of HFpEF ranging from 17% to 38%; 21,22 more recently, Yap and collaborators studied a total of 1,960 patients with heart failure, 751 (38.3%) of whom had HFpEF [23], a lower prevalence than that found in the present study.

A Vietnamese Multicenter Research was conducted to identify clinical phenotypes, as well as age-related differences in patient characteristics, treatment patterns, and in-hospital mortality rate of patients with HFPEF where females comprised 62.3% of the population. [24] The present research presented a higher percentage of women 59.85% compared to men at 44.74% with statistical significance (p=0.002).

It is known that arterial hypertension is one of the common risk factors attributable to the development of heart failure, which had a high prevalence in this population and together with other risk factors could be determinants of the behavior of heart failure in this report.

CONCLUSIONS

The levels in terms of prevalence, knowledge, and control of arterial hypertension are worrying. The prevalence of smoking in men was also high and its effects could lead to a significant number of deaths. Most patients with a history of coronary artery disease had elevated LDL-C levels based on risk. Heart failure with preserved ejection fraction predominated mainly in women.

The evidence from this study provides valuable information on the behavior of cardiovascular diseases and their risk factors and could be a guide to implementing effective interventions focused on the prevention and control of noncommunicable diseases.

Acknowledgment

We would like to disclose our genuine gratitude to the study participants who provided the survey data.

Conflicts of interest

The authors declare no potential conflict of interests.

REFERENCES

1. Tsao CW, Aday AW, Almarzooq ZI, Alonso A, Beaton AZ, Bittencourt MS, et al. American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Sub-Committee. Heart disease and stroke statistics-2022 update: a report from the American Heart Association. Circulation [Internet]. 2022 [Consulted 2022 Sep 10];145(8): e153-e639. Available from: https://www.ahajournals.org.

2. Anh Hien H, Tam NM, Tam V, Van Minh H, Hoa NP, Heytens S, et al. Estimation of the cardiovascular risk using world health organization/international society of hypertension risk prediction charts in Central Vietnam. PLOS ONE. [Internet] 2020 [Consulted 2022 Sep 10]; 15(11): e0242666. Available from: https://journals.plos.org/

3. Hien HA, Tam NM, Tam V, Derese A, Devroey D. Prevalence, awareness, treatment, and control of hypertension and its risk factors in Central Vietnam. Int J Hypertens. [Internet] 2018 [Consulted 2022 Sep 10] May 16; 2018:6326984. Available from: https://doi.org/10.1155/2018/6326984.

4. Bossone E, Majolo M, D'Ambrosio S, Raiola E, Sparano M, Russo G, et al. Management Approach for

Reengineering the Hospital Cardiology Consultation Process: A Report from AORN "A. Cardarelli" of Naples. Int J Environ Res Public Health. [Internet] 2022 [Consulted 2022 Sep 10];19(8): 4475. Available from: https://www.mdpi.com/journal/

5. Stergiou S, Palatini P, Parati G, Brien E, Januszewicz A, Lurbe E, et al. European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement. J Hypertens. [Internet] 2022[Consulted 2022 Sep 10] 39:1293-302. Available from: http://www.jhypertension.com

6. Mach F, Baigent C, Catapano A, Koskinas K, Casula M, Badimon L, et al. Guidelines for the management of dyslipidemias: lipid modification to reduce cardiovascular risk. The Task Force for the management of dyslipidemias of the European Society of Cardiology (ESC) and European Atherosclerosis Society (EAS). European Heart Journal. [Internet] 2020[Consulted 2022 Sep 10] ; 41:111-88. Available from: http://www.escardio.org/guidelines

7. Heidenreich P, Bozkurt B, Aguilar D, Allen L, Byun J, Colvin M, et al. Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. [Internet] 2022 [Consulted 2022 Sep 10] ;145(18):895-1032. Available from: https://www.ahajournals.org

8. Bui N, Pham Q, Vo L. Prevalence and Risk Factors of Hypertension in Two Communes in the Vietnam Northern Mountainous, 2017. Biomed Res Int. [Internet] 2018[Consulted 2022 Sep 10] ; 2018:7814195. Available from: https://www.ncbi.nlm.nih.gov/

9. Zamorano J, García X, Ferrari R, Greenlaw N. Demographic and Clinical Characteristics of Patients with Stable Coronary Artery Disease: Results from the CLARIFY Registry in Spain. Rev Esp Cardiol. [Internet]. 2014 [Consulted 2022 Sep 10];67(7):538-44. Available from: https://www.revespcardiol.org

10. Meiqari L, Essink D, Wright P, Scheele F. Prevalence of Hypertension in Vietnam: A Systematic Review and Meta-Analysis. Asia Pac J Public Health. [Internet]. 2019 May 3 [Consulted 2022 Sep 15];31(2):101-12. Available from: https://www.ncbi.nlm.nih.gov

11. Daisuke M, Nguyen D, Shoko M, Junko T, Hiroyuki G, Nguyen T. Dyslipidemia and cardiovascular disease in Vietnamese people with HIV on antiretroviral therapy. Global Health & Medicine. [Internet]. 2020 [Consulted 2022 Sep 15]; 2(1):39-43. Available from: http://www.globalhealthmedicine.com/

12. Pham D, Nguyen H, Pham Ch, Dung P, Phan N, Ninh N. Prevalence of Dyslipidemia and Associated Factors among Adults in Rural Vietnam. Systematic Reviews in Pharmacy. [Internet]. 2020 [Consulted 2022 Sep 15]; 11(1):185-91. Available from: https://www.researchgate.net

13. Van Minh H, Giang KB, Ngoc NB. Prevalence of tobacco smoking in Vietnam: findings from the global adult tobacco survey 2015. Int J Public Health. [Internet] 2017 [Consulted 2022 Sep 15] ; 62:121–9. Available from: https://link.springer.com/

14. World Health Organization [Internet]. Cardiovascular diseases (CVDs) in Viet Nam. [Internet]. 2018. [Consulted 2022 Sep 15]. Available from: https://www.who.int/vietnam/health-topics/cardiovascular-disease

15. Prabhakaran D, Jeemon P, Roy A. Cardiovascular Diseases in India: Current Epidemiology and Future Directions. Circulation. [Internet]. 2016 [Consulted 2022 Sep 15] ;133(16):1605-20. Available from: https://pubmed.ncbi.nlm.nih.gov/27142605/

16. Joseph P, Leong D, McKee M, Anand SS, Schwalm JD, Teo K, et al. Reducing the Global Burden of Cardiovascular Disease, Part 1: The Epidemiology and Risk Factors. Circ Res. [Internet]. 2017 [Consulted 2022 Sep 15] ;121(6):677-94. Available from: http://ahajournals.org

17. Nguyen T, Trevisan M. Vietnam a country in transition: health challenges. Bmjnph. [Internet]. 2020[Consulted 2022 Sep 15] ;0. Available from: http://nutrition.bmj.com/

18. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. Lancet. [Internet]. 2021 [Consulted 2022 Sep 15]; 398: 957-80. Available from: https://pubmed.ncbi.nlm.nih.gov

19. Burgess S, Ference BA, Staley JR, Freitag DF, Mason AM, Nielsen SF, et al. European Prospective Investigation into Cancer and Nutrition Cardiovascular Disease (EPIC-CVD) Consortium. Association of LPA variants with risk of coronary disease and the implications for lipoprotein(a)-lowering therapies: a Mendelian randomization analysis. JAMA Cardiol. [Internet]. 2018 Consulted 2022 Sep 10] ;3:619-27.

20. Available from: https://jamanetwork.com

21. Mortensen M, Caínzos-Achirica M, Steffensen H. Association of Coronary Plaque with Low-Density Lipoprotein Cholesterol Levels and Rates of Cardiovascular Disease Events Among Symptomatic Adults. JAMA Netw Open. [Internet]. 2022 [Consulted 2022 Sep 15]; 5(2): e2148139. Available from: https://jamanetwork.com

22. Leong KT, Goh PP, Chang BC, Lingamanaicker J. Heart failure cohort in Singapore with defined criteria: clinical characteristics and prognosis in a multi-ethnic hospital-based cohort in Singapore. Singapore Med J. [Internet]. 2007 Consulted 2022 Sep 10] ;48(5):408-14. Available from: http://smj.sma.org.sg

23. Lam C. Heart failure in Southeast Asia: facts and numbers. ESC Heart Failure. [Internet]. 2015 Consulted 2022 Sep 12]; 2:46-4. Available from: https://onlinelibrary.wiley.com/

24. Yap J, Sim D, Lim CP, Chia SY, Go YY, Jaufeerally FR, et.al. Predictors of two-year mortality in Asian patients with heart failure and preserved ejection fraction. Int J Cardiol. [Internet]. 2015 [Consulted 2022 Sep 14] ;183C:33–38. Available from: https://europepmc.org

25. Nguyen T, Tran T, Le P, Van S, Nguyen A, Chau N. Clinical Phenotypes and Age-Related Differences in Presentation, Treatment, and Outcome of Heart Failure with Preserved Ejection Fraction: A Vietnamese Multicenter Research. Cardiol Res Pract. [Internet]. 2021 [Consulted 2022 Sep 14]:4587678. Available from: https://www.ncbi.nlm.nih.gov

Initial assessment of the role of intra-aortic balloon pump during high-risk percutaneous coronary intervention

Hau Trung Nguyen[1]✉, Hung Manh Pham[2], Van Duy Vo[1], Hanh Duc Van[1]
Kha Quang Nguyen[1], Hoat Manh Nguyen[1], Tuan Duc Do[1]
[1] Vietnam National Heart Institute, Bach Mai Hospital
[2] Hanoi Medical University

ABSTRACT

Background: Intervention in high-risk patients with coronary artery disease has a low success rate and higher risk of complications. The intra-aortic balloon pump (IABP) is a recommended hemodynamic support device used in this patient population. However, there are still various opinions regarding the use of IABP.

Objective: (1) To describe clinical and subclinical characteristics of patients with high-risk percutaneous coronary intervention (PCI), (2) Evaluate the role of intra-aortic balloon pump (IABP) during high-risk PCI.

Materials and method: From August 2020 to October 2021, we conducted the study on 36 patient with high-risk coronary diseases in whom PCI, Among them, 16 patients underwent intervention under hemodynamic support of IABP.

Results: Thirty six patients (male 66,7%) join in the study (mean age 71,81±8,52 years). Common cardiovascular risk factors were hypertention (63,9%), smoking (47,2%) and diabetes (33,3%). The mean left ventricular ejection fraction was 34±9,71%. The mean SYNTAX score was 27,39±2,96. There were no significant differences in clinical and and subclinical characteristics between the group using and not using IABP during the intervention. In IABP group, the mean blood pressure after IABP support was significantly higher than baseline (88,31±7,39 mmHg vs 77,67±7,2 mmHg, p=0,001), the mean heart rate after IABP support was significantly lower than baseline (80,75±9,84 vs 83,93±12,66, p=0,007). The group supported by IABP had a higher rate of not using vasopressors, and the rate of using 1 vasopressor drug was less than the group without IABP support, statistically significant with p<0.05.

Conclusion: IABP can be use to support for high-risk PCI. Use of IABP reduces the proportion of patients requiring additional vasopressors to maintain hemodynamics.

I. INTRODUCTION

Percutaneous coronary intervention (PCI) is a widely used and highly effective method in treating patients with coronary artery disease. With the improvement of devices and interventionalist experience, the indications for PCI are expanding to include very complex lesions in specific populations. The consensus among interventionalists regarding the high-

Correspondence to: Dr. Hau Trung Nguyen. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam. Email: bs.nguyentrunghau@gmail.com

risk group of coronary artery disease patients includes a combination of patient characteristics such as advanced age, multiple comorbidities, with complex coronary artery lesions such as left main stem, calcified lesions, lesions in saphenous vein grafts, or triple-vessel disease, and in specific clinical settings such as acute coronary syndrome with cardiogenic shock or severe left ventricular dysfunction. For this high-risk patient population, the use of mechanical circulatory support devices during the intervention is recommended (1). The intra-aortic balloon pump (IABP) is a device that provides hemodynamic support through a counterpulsation mechanism. The balloon is inflated in the aortic root during systole and deflated during diastole. The IABP helps increase myocardial perfusion, decrease myocardial oxygen consumption, reduce afterload, and increase cardiac output. Several studies worldwide have shown that IABP is effective in reducing short-term and long-term cardiovascular events. However, there are not many studies on this issue in Vietnam. Therefore, we conducted a study with two objectives:

(1) To describe the clinical and paraclinical characteristics of high-risk patients with coronary artery disease.

(2) To preliminarily assess the role of IABP in supporting PCI in high-risk patients.

II. OBJECTIVES AND METHODS

Selection criteria:

- Patients identified as high-risk when undergoing percutaneous coronary intervention (PCI) include:

- Patients with a stenosis ≥ 70% in the left main coronary artery, with expected difficult and prolonged intervention, and with left ventricular ejection fraction (LVEF) dysfunction at any level. Or:

- Patients with severe left ventricular dysfunction (ejection fraction ≤ 35%), accompanied by a stenosis of the left main coronary artery or three major coronary arteries (≥ 50% stenosis in all 3 branches, with at least 1 branch having a stenosis ≥ 70%).

- Patients must agree to participate in the study.

Exclusion criteria:

- Patients with angiographic findings that do not meet the selection criteria.

- Patients with cardiogenic shock prior to angiography and PCI.

- Patients with mechanical complications: free wall rupture, ventricular septal rupture, acute severe mitral regurgitation due to chordal rupture.

- Patients with contraindications for intra-aortic balloon pump (IABP) placement: severe aortic regurgitation, aortic dissection, severe peripheral vascular disease.

- Patients with severe comorbidities.

- Patients who do not agree to participate in the study.

Study design: Prospective comparative intervention study. Convenience sample.

Study location: Vietnam National Heart Institute - Bach Mai Hospital.

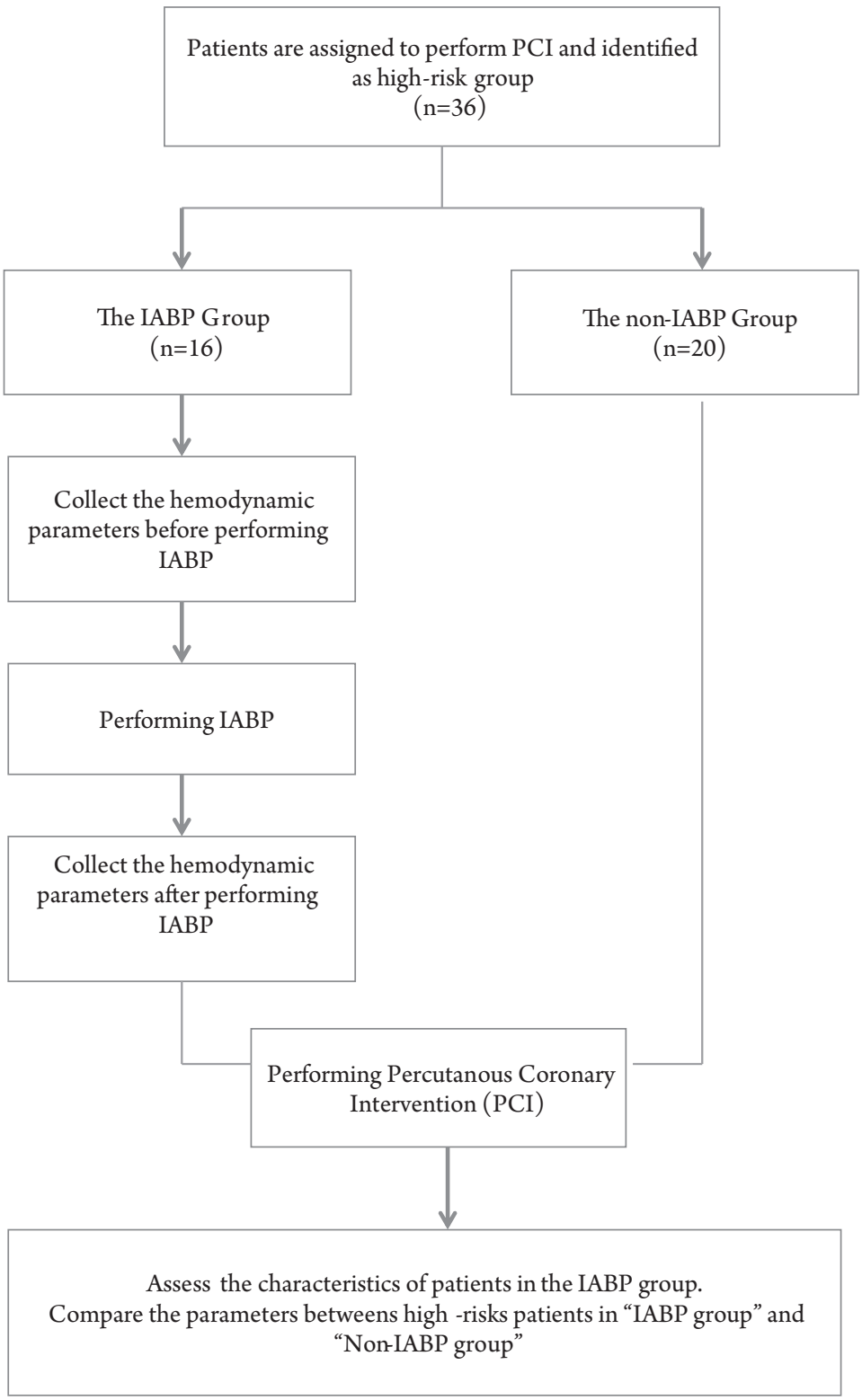
Research process:

Step 1: Collect clinical, laboratory and angiographic data of patients who meet the selection criteria.

Step 2: Perform PCI on patients. There are 2 groups of patients: 1 group uses IABP before the procedure, and 1 group does not use IABP. Record the parameters during the process.

Step 3: Evaluate the characteristics of the IABP group. Compare the parameters of the 2 groups.

Data analysis and processing: SPSS 20.0 software was used. T-test, chi-square and ANOVA tests were used if appropriate, $p < 0.05$ was considered statistically significant.


Patients are assigned to perform PCI and identified as high-risk group (n=36)
The IABP Group (n=16)
The non-IABP Group (n=20)
Collect the hemodynamic parameters before performing IABP
Performing IABP
Collect the hemodynamic parameters after performing IABP
Performing Percutanous Coronary Intervention (PCI)
Assess the characteristics of patients in the IABP group.
Compare the parameters betweens high -risks patients in "IABP group" and "Non-IABP group"

III. RESULTS

Table 1. The clinical characteristics of patients

	Sum n = 36	The IABP group n = 16	The non IABP group n = 20	p
The common characteristics				
Age X mean ± SD	71,81 ± 8,52	72,5 ± 8,14	71,25 ± 8,98	0,668
Male n (%)	24 (66,7)	11 (68,8)	13 (65)	0,813
BMI (kg/m^2) X mean ± SD	22,13 ± 2,36	22,88 ± 2,12	21,53 ± 2,42	0,09
BMI ≥ 23 (kg/m^2), n (%)	13 (36,1)	7 (43,8)	6 (30,0)	0,493
Risk factors				
Hypertension n (%)	23 (63,9)	10 (62,5)	13 (65)	0,877
Diabete n (%)	12 (33,3)	7 (43,8)	5 (25)	0,236
Smoking, n (%)	17 (47,2)	8 (50,0)	9 (45,0)	0,765
Stroke n (%)	6 (16,7)	2 (12,5)	4 (20,0)	0,672
Performance PCI n (%)	6 (16,7)	2 (12,5)	4 (20,0)	0,672
Chornic kidney disease (CKD) n (%)	7 (19,4)	2 (12,5)	5 (25)	0,426
Heart Failure n (%)	12 (33,3)	6 (37,5)	6 (30)	0,635

Between August 2020 and October 2021, 36 patients were included in the study. The average age of the patients was 71.81±8.52 years, with the majority being male (66.7%). The average BMI of the patients was 22.13±2.36, with 13 patients (36.1%) having a BMI ≥23. The most common cardiovascular risk factors were hypertension (63.9%), smoking (47.2%), and diabetes (33.3%). There was no statistically significant difference between the group that used IABP and the group that did not use IABP.

Table 2. The subclinical characteristics of patients and Syntax Score

	Sum n = 36	The IABP group n = 16	The non IABP group n = 20	p
Biochemical parameters				
Ure (mmol/L) X mean ± SD	6,73 ± 2,37	6,82 ± 2,52	6,66 ± 2,31	0,835

Glucose (mmol/L) X mean ± SD	8,33 ± 4,08	8,31 ± 4,39	8,15 ± 3,95	0,914
Creatinin (µmol/L) X mean ± SD	87,00 ± 31,11	87,19 ± 27,23	86,85 ± 34,61	0,975
GOT (U/L) X mean ± SD	101,36 ± 98,44	106 ± 97,46	97,60 ± 81,59	0,802
GPT (U/L) X mean ± SD	58,00 ± 42,12	57,94 ± 40,68	58,05 ± 41,74	0,996
Cholesterol (mmol/L) X mean ± SD	4,50 ± 0,96	4,43 ± 0,84	4,56 ± 1,07	0,680
LDL – C (mmol/L) X mean ± SD	2,49 ± 0,99	2,59 ± 1,13	2,41 ± 0,89	0,603
HDL – C (mmol/L) X mean ± SD	1,23 ± 0,45	1,34 ± 0,60	1,14 ± 0,26	0,195
Triglycerid (mmol/L) X mean ± SD	1,91 ± 1,63	2,15 ± 2,31	1,72 ± 0,76	0,425
Natri (mmol/L) X mean ± SD	137,83 ± 3,07	138,00 ± 3,48	137,70 ± 2,79	0,776
Kali (mmol/L) X mean ± SD	3,90 ± 0,49	4,00 ± 0.39	3,82 ± 0,55	0,293
Clo (mmol/L) X mean ± SD	100,64 ± 3,73	100,87 ± 4,05	100,45 ± 3,54	0,739
Troponin T (ng/L) Median {IQR}	252,60 {37,8–1455}	137,50 {36,0–2142,3}	322 {60,8– 957,3}	0,502
NT – ProBNP(pmol/L) X mean ± SD	555,26±513,45	487,91 ± 450,1	609,14 ± 564,64	0,489
CBC parameters				
Hồng cầu (T/L) X mean ± ĐLC	4,41 ± 0,65	4,19 ± 0,54	4,58 ± 0,69	0,071
Hemoglobin (g/L), X mean ± ĐLC	125,03 ± 15,43	125,00 ± 13,94	125,95 ± 16,88	0,992
Bạch cầu (G/L) X mean ± ĐLC	9,42 ± 3,15	8,44 ± 2,18	10,19 ± 3,61	0,097
Tiểu cầu (G/L) X mean ± ĐLC	282,19±112,71	303,56±141,92	265,10 ±82,52	0,316
Echocardiology				
LVEF (%) X mean ± ĐLC	34,00 ± 9,71	33,12 ± 6,48	34,70 ± 11,82	0,636
LVEF ≤35% n (%)	28 (77,8)	12 (75)	16 (80)	0,720

Syntax Score				
<33 n (%)	32 (88,9)	14 (87,5)	18 (90)	0,608
≥ 33 n (%)	4 (11,1)	2 (12,5)	2(11,1)	
SYNTAX score X mean ± SD	27,39 ± 2,96	27,44 ± 3,18	27,35 ± 2,85	0,931

The average left ventricular ejection fraction (LVEF) of the patients in the study is 34±9.71%. Common myocardial injuries were found in 9 patients (56.25%), while triple-vessel disease was found in 7 patients (43.75%). The average SYNTAX score was 27.39±2.96. Among them, 32 patients had SYNTAX scores ranging from 22-32 (88.9%). There was no statistically significant difference between the group that used an intra-aortic balloon pump (IABP) and the group that did not use an IABP.

Chart 1. Sub-groups of patients following the lesions on the DSA of cononary artery in combination with the ejection fraction of left ventricular.

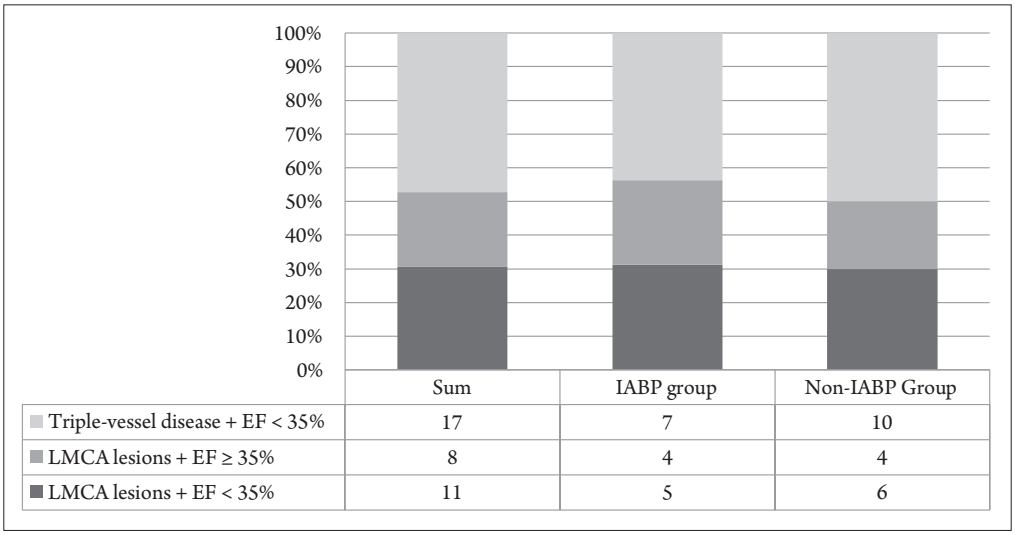


Table 3. Some changes of parameters after performing IABP or PCI.

The parameters	**Before IABP**	**After IABP**	**P**
Mean Arterial Pressure, mmHg (TB±SD)	77,67±7,20	88,31±7,39	0,001
Heart rate, bmp (TB±SD)	83,93±12,66	80,75±9,84	0,007
The parameter	**Before PCI**	**After PCI**	**P**
Creatinin, µmol/L (TB±SD)	87,19±27,23	88,81±24,37	0,547

After the placement of an intra-aortic balloon pump (IABP), the average blood pressure increased from 77.67±7.2 mmHg to 88.31±7.39 mmHg, p=0.001. The heart rate decreased from 83.93±12.66 beats per minute to 80.75±9.84 beats per minute, p=0.007. There was no statistically significant difference in the creatinine level before and after the intervention, p=0.547.

Table 4. The comparison of parameters between "the group IABP" versus "the non-IABP group" during intervention

	Sum n = 36	The IABP group n = 16	The non-IABP group n = 20	p
Site of lesions				
Left main coronary artery (LMCA), n (%)	18 (50)	9 (56,25)	9 (45)	0,502
LAD, n (%)	9 (25)	4 (25)	5 (25)	1,000
LCx, n (%)	2 (5,6)	1 (6,25)	1 (5,0)	0,871
RCA, n (%)	7 (19,4)	2 (12,5)	5 (25)	0,426
Number of stents used				
The mean of stents	1,89	2,00	1,80	0,408
1 stent, n (%)	11 (30,6)	3 (18,75)	8 (40)	0,156
2 stents, n (%)	18 (50,0)	10 (62,5)	8 (40,0)	0,180
3 stents, n (%)	7 (19,4)	2 (12,5)	5 (25,0)	0,631
Number of inotropic drugs used				
None	20 (55,6)	13 (81,25)	7 (35,0)	0,008
1 Inotropic drug	14 (38,9)	2 (12,5)	12 (60,0)	0,006
2 Inotropic drugs	2 (5,6)	1 (6,25)	1 (5)	0,871
Time of hospitalization				
Days X mean ± SD	5,69 ± 2,38	6,31 ± 2,94	5,2 ± 1,73	0,166
Main outcomes				
Death, n (%)	3 (8,3)	1 (6,25)	2 (10,0)	0,585
Hospital discharge, n (%)	33 (91,7)	15 (93,75)	18 (90)	

The group that used an intra-aortic balloon pump (IABP) had a statistically significant lower rate of requiring multiple vasopressors and a higher rate of using a single vasopressor than the group that did not use an IABP, with $p<0.05$.

IV. DISCUSSION

We conducted a study on 36 patients identified as high-risk coronary artery disease undergoing percutaneous intervention. High-risk coronary artery disease was defined as patients with severe stenosis in the left main coronary artery with a risk of hemodynamic collapse or those with a left ventricular ejection fraction ≤35% with significant stenosis in all three coronary arteries. The mean age of the patients in the study was 71.81±8.52 years, and males accounted for 66.7% of the patients. Our results are consistent with other studies that found that patients with high-risk coronary artery disease have a mean age of >60 years and are predominantly male. Perera et al. found a mean age of 71±9.5 years with 79.4% males in their study of 301 high-risk coronary artery disease patients (2). Briguori et al. reported a mean age of 65.6±9.7 years with 88.6% males in their study of high-risk coronary artery disease patients (3). The common cardiovascular risk factors in our study were hypertension (63.9%), smoking (47.2%), and diabetes (33.3%). These were

also the high-risk factors in other studies. Perera et al. reported hypertension and diabetes rates of 61.8% and 35.2%, respectively, in their study (2). Mishra et al. found that hypertension accounted for 72.2% and diabetes accounted for 43.8% of their patients (4). In addition, 36.1% of our patients had a BMI ≥23 (kg/m2), indicating that more than one-third of the patients were overweight according to the classification for Asian people (5).

The average LVEF on echocardiography is 34.00 ± 9.71%, with severe reduction according to the American Society of Echocardiography 2015 guidelines (6). Reduced LVEF is an independent prognostic factor for mortality in patients undergoing coronary intervention. Mamas' study on the impact of left ventricular function on the outcomes of PCI showed that patients with LVEF <30% had a 7.25-fold higher mortality rate, while those with LVEF 30-40% had a 2.9-fold higher mortality rate compared to patients with LVEF >50%, with a statistically significant difference with p <0.0001 (7). All patients in our study had complex coronary artery disease, with involvement of all three coronary arteries or severe stenosis at the left main stem. The more complex the coronary artery disease, the higher the incidence of cardiovascular events during intervention. The average SYNTAX score of patients was 27.39 ± 2.96. The SYNTAX score is used to assess the complexity of coronary artery disease, with higher scores indicating greater complexity and more cardiovascular events during intervention (8). Combined with the high average age, high cardiovascular risk factors, and low ejection fraction, the study population had a high risk of hemodynamic collapse during coronary intervention, and the use of hemodynamic support devices in these patients was necessary and appropriate.

Currently, IABP is inserted into the aorta through the skin, usually from the femoral artery using the Seldinger technique. In our study, 100% of IABP placement procedures were successfully performed. After the intervention process is completed, if the patient's arterial blood pressure is stable and no additional vasopressors are required, the balloon is immediately removed in the intervention room. If the arterial blood pressure still needs support, the balloon will be maintained and moved with the patient to the intensive care unit for monitoring, and removed when the arterial blood pressure improves. The use of IABP significantly increased the mean arterial blood pressure of patients in the study from 77.67±7.20 mmHg to 88.31±7.39 mmHg (p=0.001) and significantly reduced the mean heart rate from 83.93±12.66 beats per minute to 80.75±9.84 beats per minute (p=0.007). According to Akyurekli's study on the determination of factors affecting cardiac oxygen consumption and the effectiveness of IABP in reducing cardiac load during systole, it was found that IABP reduced heart rate and increased left ventricular ejection fraction (9). Tran Duy Anh's study also reported the effectiveness of IABP in reducing heart rate and increasing mean arterial blood pressure in subjects with heart failure supported by IABP (10).

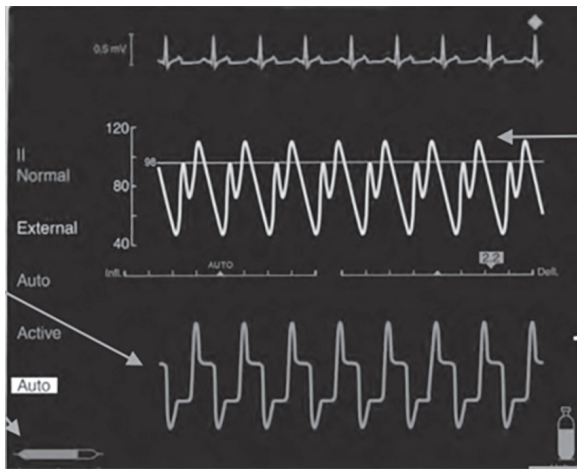


Figure 2. IABP 1:1

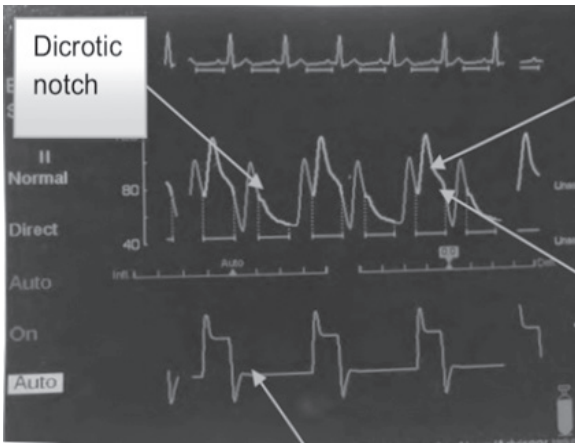


Figure 3. IABP 1:2

The support of IABP through the pump operation of the balloon during the period of diastolic helps increase coronary artery perfusion, increase blood flow through narrow vascular injuries to nourish the heart muscle. During the cardiac relaxation period, the balloon is quickly deflated to create negative pressure in the main artery to reduce afterload, increase the flow index, and reduce the cardiac workload, thereby reducing the demand for myocardial oxygen consumption. The presence and operation of IABP may reduce the risk of hypotension and the need for additional vasodilator drugs to maintain blood pressure. In our study, 81.25% of patients in the IABP-supported group did not need additional vasodilator drugs during and after the intervention, compared to 35% in the non-IABP group, with a significant difference at p=0.008. Perera et al., when comparing two high-risk PCI intervention groups with or without active IABP use, noted that in the non-IABP group, 18 patients (12%) had to undergo emergency IABP placement during the intervention, with 13 patients due to hypotension and one patient due to pulmonary edema. These patients did not differ from patients who did not require emergency IABP placement in terms of clinical characteristics and left ventricular ejection fraction, but had a significantly higher incidence of coronary artery injury (2). Briguori's study reported a 15% incidence of hypotension in high-risk coronary artery intervention patients who did not receive IABP support (3). Mishra reported a 22% mortality rate in the hospital in the group of high-risk coronary artery intervention patients who received IABP rescue due to complications of the intervention process (4). With a relatively high proportion of patients in the non-IABP group experiencing hemodynamic disorders and requiring emergency IABP placement (15% in Briguori's study, 12% in Perera's study), it underscores the importance of preventative strategies for mechanical circulatory support devices, including IABP, during high-risk PCI interventions. Therefore, IABP still plays a necessary role as a support device recommended by the World Heart Association for high-risk coronary artery interventions.

V. LIMITATIONS OF THE STUDY

Our study has some limitations. Firstly, the sample size of the study is modest due to strict selection criteria and a short study duration. Secondly, the patient grouping was not randomized, and the decision to use IABP depended on the operator's choice, which is also a limitation of the study.

VI. CONCLUSION

IABP should be used to support interventions in high-risk coronary artery disease patients to improve hemodynamics during the procedure. The use of IABP reduces the proportion of patients who require additional vasopressor medications to maintain hemodynamics

REFERENCES

1. Rihal CS, Naidu SS, Givertz MM, Szeto WY, Burke JA, Kapur NK, et al. 2015 SCAI/ACC/HFSA/STS Clinical Expert Consensus Statement on the Use of Percutaneous Mechanical Circulatory Support Devices in Cardiovascular Care: Endorsed by the American Heart Assocation, the Cardiological Society of India, and Sociedad Latino Americana de Cardiologia Intervencion; Affirmation of Value by the Canadian Association of Interventional Cardiology-Association Canadienne de Cardiologie d'intervention. J Am Coll Cardiol. 2015 May 19;65(19):e7–26.

2. Perera D, Stables R, Thomas M, Booth J, Pitt M, Blackman D, et al. Elective intra-aortic balloon counterpulsation during high-risk percutaneous coronary intervention: a randomized controlled trial. JAMA. 2010 Aug 25;304(8):867–74.

3. Briguori C, Sarais C, Pagnotta P, Airoldi F, Liistro F, Sgura F, et al. Elective versus provisional intra-aortic balloon pumping in high-risk percutaneous transluminal coronary angioplasty. Am Heart J. 2003 Apr;145(4):700–7.

4. Mishra S, Chu WW, Torguson R, Wolfram R, Deible R, Suddath WO, et al. Role of prophylactic intra-aortic balloon pump in high-risk patients undergoing percutaneous coronary intervention. Am J Cardiol. 2006 Sep 1;98(5):608–12.

5. Pan W-H, Yeh W-T. How to define obesity? Evidence-based multiple action points for public awareness, screening, and treatment: an extension of Asian-Pacific recommendations. Asia Pac J Clin Nutr. 2008;17(3):370–4.

6. Lang RM, Badano LP, Mor-Avi V, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *J Am Soc Echocardiogr Off Publ Am Soc Echocardiogr*. 2015;28(1):1-39.e14. doi:10.1016/j.echo.2014.10.003

7. Mamas MA, Anderson SG, O'Kane PD, et al. Impact of left ventricular function in relation to procedural outcomes following percutaneous coronary intervention: insights from the British Cardiovascular Intervention Society. *Eur Heart J*. 2014;35(43):3004-3012a. doi:10.1093/eurheartj/ehu303

8. Mohr FW, Morice MC, Kappetein AP, et al. Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial. *Lancet Lond Engl*. 2013;381(9867):629-638. doi:10.1016/S0140-6736(13)60141-5

9. Akyurekli Y, Taichman GC, Keon WJ. Effectiveness of intra-aortic balloon counterpulsation on systolic unloading. *Can J Surg J Can Chir*. 1980;23(2):122-126.

10. Trần Duy Anh, Nguyễn Thị Quý. Tổng quan về bóng đối xung nội động mạch chủ. *Y học thực hành (835-836)*. 2012.

Influence of SCAI stage transition on clinical outcomes in patients with acute myocardial infarction

Hung Manh Pham [1,2], Hanh Duc Van [1]✉

[1] Vietnam National Heart Institute, Bach Mai Hospital

[2] Hanoi Medical University

ABSTRACT

Objective: To describe the association between the transition of SCAI stage and clinical outcomes in patients with acute myocardial infarction.

Subjects and methods: A cross-sectional study on 156 patients with acute myocardial infarction at Heart Institute, Bach Mai Hospital from 8/2022 to 2/2023. Clinical status, laboratory parameters and SCAI classification were assessed at the time of admission and 24 hours after admission. Clinical outcomes at the hospital included death and the patient was discharged in severe condition.

Results: The distribution of the patients across SCAI shock stages on admission was 46.2%, 19.2%, 30.8%, 2.5% and 1.3% to A, B, C, D and E, respectively. Statistically significant difference in SCAI stages were observed in clinical and laboratory parameters such as heart rate, cardiac biomarker concentrations, pH and blood lactate. The clinical outcomes were significantly higher in the more severe SCAI stage. The SCAI shock transition was determined at 24 hours, 14.1% improved, 60.3% remained and 25.6% worsened SCAI stage. Improved SCAI stages were associated with better clinical outcomes (OR 0.06; 95% CI 0.02 – 0.14). Worse SCAI stages were associated with an increase in clinical outcomes (OR 9.00; 95% CI 3.20–25.29).

Conclusion: Transitions of SCAI stage are valuable in predicting clinical outcomes in patients with acute myocardial infarction.

Keywords: Acute myocardial infarction, cardiogenic shock, SCAI classification.

INTRODUCTION

Cardiogenic shock due to myocardial infarction is a major challenge in clinical practice even in developed countries. The incidence of cardiogenic shock is about 5.9 - 8.3% of patients with acute myocardial infarction.[1,2] Early revascularization and culprit only revascularization in patients with cardiogenic shock due to myocardial infarction have been shown to improve cardiovascular events.[3–5] Other management strategies in acute myocardial infarction associated cardiogenic shock such as hypothermia and left ventricular assist devices have not been shown to improve mortality in the short or long term.[6–9] Therefore, the hospital mortality rate due to cardiogenic shock in patients with acute myocardial infarction is nearly 40 - 50% and does not seem to have changed in the last 20 years.[1,10–13] Cardiogenic shock team is a working group of many doctors in different specialties including critical care cardiology, advanced heart failure, interventional cardiology, cardiac surgery and

Correspondence to: Dr. Hanh Duc Van. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam. Email: duchanhvan@gmail.com

ECMO service has been shown to be independent factor in improve clinical outcomes.[14,15]

Many different criteria have been published for the diagnosis and classification of cardiogenic shock but there is no common consensus among these criteria, which makes it difficult to practice and conduct research. In order to overcome these difficulties, the Society for Cardiovascular Angiography and Intervention (SCAI) and 8 other organizations including American College of Cardiology (ACC), American College of Emergency Physicians (ACEP), American Heart Association (AHA), European Society of Cardiology (ESC), Association for Acute Cardiovascular Care (ACVC), International Society for Heart and Lung Transplantation (ISHLT), Society of Critical Care Medicine (SCCM) and Society of Thoracic Surgeons (STS) released the 2021 updated SCAI shock classification which replaced 2019 SCAI classification.[16,17] Three important domains including physical examination, biochemical, and hemodynamic criteria has been maintained in the updated SCAI classification. Importantly, the authors divided them into "typically include" and "may include" to emphasize cardiogenic shock stage. Thus, cardiogenic shock is not a disease stage but a continuous progression from A (At Risk) to B (Beginning), C (Classic), D (Deteriorating) and E (Extremis). The SCAI shock classification is an indication of shock severity and comprises one component of mortality risk prediction in patients with cardiogenic shock.[17] In the year of 2022, Consensus of the Vietnam National Heart Association on diagnosis and management of Cardiogenic Shock was impressed the role of SCAI shock classification in clinical practice.[18] This study was conducted to evaluate the effectiveness of SCAI classification on admission and SCAI stage transition in the clinical outcomes at the hospital of patients with acute myocardial infarction.

METHOD

Study population

This cross-sectional study included 156 patients with acute myocardial infarction at the Vietnam Heart Institute, Bach Mai Hospital from August 2022 to February 2023. ST segment elevation myocardial infarction patients were diagnosed according to the 2018 Fourth universal definition of myocardial infarction.[19] Non-ST-segment elevation myocardial infarction were diagnosed according to the 2020 European Society of Cardiology guideline.[20]

Data sources

We collected demographic, vital sign, medical histories, laboratory parameters and clinical outcomes data, as well as procedures and therapies performed during hospital stay. The vital signs, clinical measurements and laboratory values were recorded both on admission and 24 hours after admission.

SCAI SHOCK classification criteria and outcomes

Patients were assigned to a SCAI stage due to Updated SCAI shock classification at the time of admission and 24 hours after admission. SCAI A defines stage A patients as those at risk for cardiogenic shock and stable hemodynamic. Stage B patients are those exhibiting early symptoms including hypotension and/or tachycardia but not including hypo-perfusion and, therefore, do not require pharmacological or mechanical support. Stage C patients are those with hypo-perfusion (lactic acidosis, oliguria, cool/ clammy periphery, or altered mentation) requiring initial intervention. Stage D patients are those whose condition deteriorates despite initial intervention. Finally, stage E patients are those who have deteriorated further or impending circulatory collapse, including cardiac arrest with ongoing resuscitation.

The SCAI SHOCK stage at 24 hours was

compared to that at initial assessment. The group was divided into patients who have a better SCAI stage, unchanged and worse SCAI stage at 24 hours. Better SCAI stage was defined as lower SCAI stage and worse SCAI stage was higher SCAI stage at 24 hours.

Clinical outcomes at the hospital were death status and severe condition at discharge.

Statistical analysis

Patients were divided into 5 groups: SCAI A, SCAI B, SCAI C, SCAI D, and SCAI E. Baseline descriptive clinical and biochemical characteristics were summarized as mean and standard deviation for continuous variables and proportions for categorical variables, stratified by SCAI stage. Groups were compared using ANOVA test for continuous variables and χ^2 tests for categorical variables. P values with a significance level of $\alpha = 0.05$. Odd ratio (OR) and 95% CI were used to measure the association between the clinical outcomes and the transition of SCAI stage. Statistical analysis was performed using STATA 14.0 and SPSS 20.0.

RESULTS

156 patients with acute myocardial infarction including 109 patients with ST-segment elevation myocardial infarction and 47 patients with non-ST-segment elevation myocardial infarction. The general characteristics of the group are presented in Table 1.

Table 1. General characteristics of patients with acute myocardial infarction

	Result
Age[1]	68.9 ± 12.4
Female sex[2]	49 (31.4)
Hypertension[2]	99 (63.5)
Diabetes mellitus[2]	38 (24.4)
Prior myocardial infarction[2]	22 (14.1)
Prior stroke[2]	11 (7.1)
Chronic kidney disease[2]	4 (2.6)
Smoking[2]	13 (8.4)
Systolic blood pressure (mmHg)[2]	118.1 ± 27.3
Heart rate (beat per minute)[1]	87.0 ± 24.7
Creatinine (µmol/L)[1]	109.7 ± 81.6
NT-proBNP (pg/mL)[1]	9220.5 ± 11404.8
Troponin T (ng/L)[1]	2104.6 ± 2597.6
pH[1]	7.4 ± 0.1
Lactate (mmol/L)[1]	4.3 ± 4.5
EF (%)[1]	46.2 ± 12.2
Death status or severe condition at discharge[2]	42 (26.9)

[1] Data is presented as mean ± standard deviation,

[2] Data is presented as percentage

Cardiogenic shock is a continuum rather than a disease phase. The SCAI classification at the time of admission of patients with acute myocardial infarction is described in Table 2.

Table 2. SCAI classification at the time of admission in myocardial infarction patients

	SCAI A (n = 72)	**SCAI B (n = 30)**	**SCAI C (n = 48)**	**SCAI D (n = 4)**	**SCAI E (n = 2)**	**p**
Age[1]	65.6 ± 13.0	70.8 ± 10.4	74.3 ± 10.5	86.5 ± 5.6	73.5 ± 2.1	0.12
Female sex[2]	15 (20.8)	13 (43.3)	18 (37.5)	3 (75.0)	0 (0.0)	0.03
Hypertension	43 (59.7)	19 (63.3)	33 (68.8)	3 (75.0)	1 (50.0)	0.84

	SCAI A (n = 72)	SCAI B (n = 30)	SCAI C (n = 48)	SCAI D (n = 4)	SCAI E (n = 2)	p
Diabetes mellitus[2]	10 (13.9)	12 (40.0)	13 (27.1)	2 (50.0)	1 (50.0)	0.03
Prior myocardial infarction[2]	10 (13.9)	4 (13.3)	6 (12.5)	1 (25.0)	1 (50.0)	0.62
Prior stroke[2]	5 (6.9)	2 (6.7)	3 (6.3)	0 (0.0)	1 (50.0)	0.20
Chronic kidney disease[2]	0 (0.0)	1 (3.3)	3 (6.3)	0 (0.0)	0 (0.0)	0.32
Smoking[2]	3 (4.2)	3 (1.0)	6 (12.5)	1 (25.0)	0 (0.0)	0.36
Systolic blood pressure[2]	133.2 ± 19.7	122.7 ± 20.2	99.9 ± 14.9	88.8 ± 20.2	0 ± 0	0.20
Heart rate[1]	80.0 ± 14.8	89.5 ± 22.9	97.8 ± 28.4	98.3 ± 45.1	20.0 ± 28.3	0.00
Creatinine (µmol/L)[1]	85.3 ± 24.9	101.0 ± 54.8	129.3 ± 53.2	130.5 ± 24.2	581.0 ± 496.4	0.00
NT-proBNP (pg/mL)[1]	1146.2 ± 1120.1	7302.4 ± 10320.8	14559.8 ± 12024.3	11919.8 ± 15813.7	22065.5 ± 12633.9	0.00
Troponin T (ng/L)[1]	1297.9 ± 1909.9	1702.8 ± 2028.8	3589.8 ± 3274.9	1771.3 ± 671.7	2193.0 ± 2003.9	0.00
pH[1]	7.4 ± 0.4	7.4 ± 0.5	7.4 ± 0.1	7.2 ± 0.1	7.3 ± 0.7	0.00
Lactate (mmol/L)[1]	1.2 ± 0.5	2.2 ± 1.3	4.1 ± 2.3	14.3 ± 3.3	21.0 ± 1.4	0.00
EF (%)[1]	53.4 ± 9.1	41.9 ± 11.2	38.6 ± 9.3	32.0 ± 9.4	49.5 ± 34.7	0.047
Death or severe status at discharge[2]	0 (0.0)	7 (23.3)	29 (60.4)	4 (100)	2 (100)	0.00

[1]Data is presented as mean ± standard deviation, [2]Data is presented as percentage

The transition in SCAI classification at 24 hours from admission in relation to clinical outcomes is presented in Tables 3 and 1

Table 3. Relationship between the SCAI classification transition and clinical outcomes

	Non death and severe condition at discharge	Death or severe condition at discharge	p
Better SCAI stage	21 (18.4)	1 (2.4)	0,000
Unchanged SCAI stage	89 (78.1)	5 (11.9)	
Worse SCAI stage	4 (3.5)	36 (85.7)	

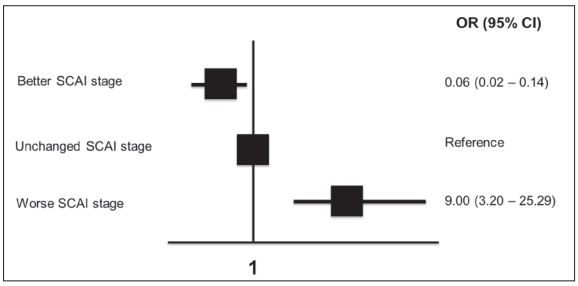


Figure 1. The association between SCAI classification transition and clinical outcomes

DISCUSSION

In this study of acute myocardial infarction, we stratified patients into 5 SCAI shock stages at the time of admission, reflecting a continuum of increasing shock severity using a simplified definition based on hypotension or tachycardia, hypo-perfusion, deterioration and refractory shock, which can be easily applied in clinical practice. The proportion of patients with SCAI shock stages A through E were 46.2%, 19.2%, 30.8%, 2.5% and 1.3%, respectively.

Baseline demographics, medical histories, comorbidities, laboratory parameters were presented detailly in Table 1. The average age of patients was 68.9 ± 12.4 years old. Most patients were male (68.6%). Hypertension, diabetes, and smoking are important risk factors for myocardial infarction. The rates of hypertension, diabetes and smoking in our study were 63.5%, 24.4% and 8.4%, respectively. The age of the patients and the proportion of female in our study were statistically significant higher than these characteristics in studies of Shrage and Hanson.[21,22] Population in Shrage's study were cardiogenic shock due to acute myocardial infarction complication, non-ischemic diseases and prior cardiopulmonary resuscitation. Patients in Hanson's study were acute myocardial infarction which was similar to ours.[22] The mean systolic blood pressure in our study was 118.1 ± 27.3 mmHg, which was statistically significantly higher than this parameter in Shrage's study, which was 113.7 mmHg ($p<0.05$). The average heart rate in our study was 87.0 ± 24.7 beats per minute, and was similar to Shrage's study, which was 87.7 beats per minute.[21] The rate of patients who were in death status or severe condition at discharge in our study was 26.9%.

Baseline characteristics per SCAI stage were shown in Table 2. We found no differences in mean age, history of smoking, history of diabetes, history of stroke, chronic kidney disease across different SCAI stages. The study with a population of more than 1000 patients by Schrage showed that there was a statistically significant difference in these above research parameters, but it was not clear to demonstrate the trend of increase or decrease of the parameters in different SCAI stages.[21] Proportion of women and clinical parameters at the time of admission such as heart rate, creatinine concentration, NT-proBNP concentration, troponin T concentration, pH, blood lactate concentration and left ventricular ejection fraction (EF) were statistically significant difference across SCAI stages. Heart rate tends to increase gradually according to the severity of cardiogenic shock. Table 2 showed the heart rate was lowest in SCAI A and highest in SCAI D but then decreased deeply in SCAI E. Concentration of creatinine was found to increase gradually as the grade of shock progressed. Similar results were observed when analyzing the concentration of NT-proBNP, troponin T, blood lactate. These results were similar to those in Schrage's study (2019) or Thayer's study (2020).[21,23] The development of cardiogenic shock is often directly related to the degree of myocardial damage. Progressive cardiogenic shock due to the ventricle can not pump effectively, leading to a decrease in stroke volume and cardiac output causing systemic hypo-perfusion. On the other hand, sympathetic

nervous system and systemic inflammation may play a role limiting the peripheral vascular compensatory response and may contribute to making the situation worse.[24,25,26] In light of the complex pathophysiology of cardiogenic shock, it is not surprising that heart rate, cardiac biomarkers, creatinine concentration, pH, blood lactate concentration will get worse as cardiogenic shock progresses.

The rates of clinical outcomes including death and serious status at discharge of patients with acute myocardial infarction increased as cardiogenic shock progressively worsened (Figure 2). The clinical outcomes rate from classic shock to critical stage in our study was 64.8% (35/54 patients). In which, the highest mortality rate was in SCAI D and SCAI E. With longer follow-up, the higher the SCAI classification, the worse outcomes within 30 days, 180 day, 1 year and 5 years after discharge.[21,27–29]

The transition of SCAI classification and clinical outcomes at the hospital

The SCAI classification was re-evaluated 24 hours after the patient was admitted to the hospital. The results show that at 24 hours, the proportion of SCAI grades A, B, C, D and E is 55.1%, 12.2%, 7.1%, 16.6% and 9.0%, respectively. For patients initially assessed, 14.1% improved SCAI stage, 60.3% remained at the SCAI stage and 25.6% worsened SCAI stage. We found a statistically significant difference in clinical outcomes when monitoring the progression of cardiogenic shock according to SCAI classification (Table 3). The clinical outcomes rate was lowest in the improved SCAI group (2.4%), higher than in the group with the same SCAI classification (11.9%) and highest in the SCAI group with progressive deterioration (85.7%). On the other hand, the OR correlation coefficient analyzing was proven that there is a very close correlation between the transition of the SCAI stage and clinical outcomes at the hospital. Patients with better SCAI stage at 24 hours have better prognosis, whereas patients with a worsening SCAI stage will have a worse prognosis for the outcome. When cardiogenic shock patients were followed longer, the difference still showed the same results. Baran and colleagues examined 166 patients with acute myocardial infarction and showed that the 24 hours reassessment of shock stage predicted 60-day mortality and 180-day mortality after discharge.[29]

Our study demonstrated that a down-grade SCAI stage at 24 hours after admission will predict better clinical outcomes. While the mortality rate of acute myocardial infarction with cardiogenic shock improved difficultly by current strategies, early assessment and early treatment to avoid severe prognosis may improve prognosis. Further trials will be conducted to prove this issue.

Limitations

Firstly, this is a prospective series of a relatively small number of patients in a single center. Secondly, we do not have long-term follow up is a limitation. In addition, invasive pulmonary artery catheter was not measured and laboratory parameters such as lactate and biomarkers were not taken in all patients.

CONCLUSIONS

Assessment of the SCAI shock stage on admission and 24 hours after admission on 156 patients with acute myocardial infarction resulted in:

There was a statistically significant difference in clinical and laboratory parameters such as female proportion, heart rate, creatinine concentration, NT-proBNP concentration, troponin T concentration, pH and blood lactate in different SCAI stages.

Clinical outcomes including death and severe condition at discharge increased as SCAI stage progressed worse.

Re-assessment of the SCAI stage at 24 hours predicted clinical outcomes.

REFERENCES

1. Goldberg RJ, Samad NA, Yarzebski J, Gurwitz J, Bigelow C, Gore JM. Temporal Trends in Cardiogenic Shock Complicating Acute Myocardial Infarction. *N Engl J Med*. 1999;340(15):1162-1168. doi:10.1056/NEJM199904153401504

2. Jeger RV, Radovanovic D, Hunziker PR, et al. Ten-Year Trends in the Incidence and Treatment of Cardiogenic Shock. *Ann Intern Med*. 2008;149(9):618. doi:10.7326/0003-4819-149-9-200811040-00005

3. Hochman JS, Sleeper LA, Webb JG, et al. Early Revascularization and Long-term Survival in Cardiogenic Shock Complicating Acute Myocardial Infarction. *JAMA*. 2006;295(21):2511. doi:10.1001/jama.295.21.2511

4. Thiele H, Akin I, Sandri M, et al. PCI Strategies in Patients with Acute Myocardial Infarction and Cardiogenic Shock. *N Engl J Med*. 2017;377(25):2419-2432. doi:10.1056/NEJMoa1710261

5. Thiele H, Akin I, Sandri M, et al. One-Year Outcomes after PCI Strategies in Cardiogenic Shock. *N Engl J Med*. 2018;379(18):1699-1710. doi:10.1056/NEJMoa1808788

6. Fuernau G, Beck J, Desch S, et al. Mild Hypothermia in Cardiogenic Shock Complicating Myocardial Infarction: Randomized SHOCK-COOL Trial. *Circulation*. 2019;139(4):448-457. doi:10.1161/CIRCULATIONAHA.117.032722

7. Thiele H, Jobs A, Ouweneel DM, et al. Percutaneous short-term active mechanical support devices in cardiogenic shock: a systematic review and collaborative meta-analysis of randomized trials. *Eur Heart J*. 2017;38(47):3523-3531. doi:10.1093/eurheartj/ehx363

8. Bochaton T, Huot L, Elbaz M, et al. Mechanical circulatory support with the Impella® LP5.0 pump and an intra-aortic balloon pump for cardiogenic shock in acute myocardial infarction: The IMPELLA-STIC randomized study. *Arch Cardiovasc Dis*. 2020;113(4):237-243. doi:10.1016/j.acvd.2019.10.005

9. Dhruva SS, Ross JS, Mortazavi BJ, et al. Association of Use of an Intravascular Microaxial Left Ventricular Assist Device vs Intra-aortic Balloon Pump With In-Hospital Mortality and Major Bleeding Among Patients With Acute Myocardial Infarction Complicated by Cardiogenic Shock. *JAMA*. 2020;323(8):734. doi:10.1001/jama.2020.0254

10. Babaev A, Frederick PD, Pasta DJ, et al. Trends in Management and Outcomes of Patients With Acute Myocardial Infarction Complicated by Cardiogenic Shock. *JAMA*. 2005;294(4):448. doi:10.1001/jama.294.4.448

11. Goldberg RJ, Spencer FA, Gore JM, Lessard D, Yarzebski J. Thirty-Year Trends (1975 to 2005) in the Magnitude of, Management of, and Hospital Death Rates Associated With Cardiogenic Shock in Patients With Acute Myocardial Infarction: A Population-Based Perspective. *Circulation*. 2009;119(9):1211-1219. doi:10.1161/CIRCULATIONAHA.108.814947

12. Awad HH, Anderson FA, Gore JM, Goodman SG, Goldberg RJ. Cardiogenic shock complicating acute coronary syndromes: Insights from the Global Registry of Acute Coronary Events. *Am Heart J*. 2012;163(6):963-971. doi:10.1016/j.ahj.2012.03.003

13. Kolte D, Khera S, Aronow WS, et al. Trends in Incidence, Management, and Outcomes of Cardiogenic Shock Complicating ST-Elevation Myocardial Infarction in the United States. *J Am Heart Assoc*. 2014;3(1):e000590. doi:10.1161/JAHA.113.000590

14. Warren AF, Rosner C, Gattani R, Truesdell AG, Proudfoot AG. Cardiogenic Shock: Protocols, Teams, Centers, and Networks. *US Cardiol Rev*. 2021;15:e18. doi:10.15420/usc.2021.10
15. Moghaddam N, Diepen S, So D, Lawler PR, Fordyce CB. Cardiogenic shock teams and centres: a contemporary review of multidisciplinary care for cardiogenic shock. *ESC Heart Fail*. 2021;8(2):988-998. doi:10.1002/ehf2.13180
16. Baran DA, Grines CL, Bailey S, et al. SCAI clinical expert consensus statement on the classification of cardiogenic shock: This document was endorsed by the American College of Cardiology (ACC), the American Heart Association (AHA), the Society of Critical Care Medicine (SCCM), and the Society of Thoracic Surgeons (STS) in April 2019. *Catheter Cardiovasc Interv*. Published online May 19, 2019:ccd.28329. doi:10.1002/ccd.28329
17. Naidu SS, Baran DA, Jentzer JC, et al. SCAI SHOCK Stage Classification Expert Consensus Update: A Review and Incorporation of Validation Studies. *J Am Coll Cardiol*. 2022;79(9):933-946. doi:10.1016/j.jacc.2022.01.018
18. File_khuyencao2022_Soctim.pdf.
19. Thygesen K, Alpert JS, Jaffe AS, et al. Fourth universal definition of myocardial infarction (2018). *Eur Heart J*. 2019;40(3):237-269. doi:10.1093/eurheartj/ehy462
20. Collet JP, Thiele H, Barbato E, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *Eur Heart J*. 2021;42(14):1289-1367. doi:10.1093/eurheartj/ehaa575
21. Schrage B, Dabboura S, Yan I, et al. Application of the SCAI classification in a cohort of patients with cardiogenic shock. *Catheter Cardiovasc Interv*. 2020;96(3). doi:10.1002/ccd.28707
22. Hanson ID, Tagami T, Mando R, et al. SCAI shock classification in acute myocardial infarction: Insights from the National Cardiogenic Shock Initiative. *Catheter Cardiovasc Interv*. 2020;96(6):1137-1142. doi:10.1002/ccd.29139
23. Thayer KL, Zweck E, Ayouty M, et al. Invasive Hemodynamic Assessment and Classification of In-Hospital Mortality Risk Among Patients With Cardiogenic Shock. *Circ Heart Fail*. 2020;13(9):e007099. doi:10.1161/CIRCHEARTFAILURE.120.007099
24. McAtee ME. Cardiogenic Shock. *Crit Care Nurs Clin North Am*. 2011;23(4):607-615. doi:10.1016/j.ccell.2011.09.001
25. Hollenberg SM, Kavinsky CJ, Parrillo JE. Cardiogenic Shock. *Ann Intern Med*. 1999;131(1):47. doi:10.7326/0003-4819-131-1-199907060-00010
26. Reynolds HR, Hochman JS. Cardiogenic Shock: Current Concepts and Improving Outcomes. *Circulation*. 2008;117(5):686-697. doi:10.1161/CIRCULATIONAHA.106.613596
27. Jentzer JC, Baran DA, van Diepen S, et al. Admission Society for Cardiovascular Angiography and Intervention shock stage stratifies post-discharge mortality risk in cardiac intensive care unit patients. *Am Heart J*. 2020;219:37-46. doi:10.1016/j.ahj.2019.10.012
28. Jentzer JC, van Diepen S, Barsness GW, et al. Cardiogenic Shock Classification to Predict Mortality in the Cardiac Intensive Care Unit. *J Am Coll Cardiol*. 2019;74(17):2117-2128. doi:10.1016/j.jacc.2019.07.077
29. Baran DA, Long A, Badiye AP, Stelling K. Prospective validation of the SCAI shock classification: Single center analysis. *Catheter Cardiovasc Interv*. 2020;96(7):1339-1347. doi:10.1002/ccd.29319

Results of using 7 French Glidesheath slender® for complex transradial coronary interventions - First experience in Vietnam

Huy The Nguyen[1]✉, Hau Trung Nguyen[2], Tuan Minh Pham[2], Hung Manh Pham[2]
Hieu Ba Tran[2], Huynh Van Nguyen[1], Don Van Tran[1], Nhat Van Dang[1]

[1] E Hospital

[2] Vietnam National Heart Institute, Bach Mai Hospital

BACKGROUND:

Objective: Evaluate results of using 7 French guiding catheter with 7 French Glidesheath slender for complex transradial coronary interventions.

Materials and method: From October 2020 to September 2021, we conducted the study on 44 patients with complex transradial coronary interventions in whom PCI using 7 French Glidesheath slender was performed at E hospital.

Results: Fourty four patients (86,4% males) underwent complex transradial coronary interventions with 7 French Glidesheath slender support (mean age 67,2±9,12 years). Common cardiovascular risk factor was hypertention. The rate of successful placement of the 7F Glidesheath slender was 97.7%. The successful intervention rate for target lesions is 90.9%. Among coronary artery lesions, the highest rates were left main lesions (38.6%) and chronic total occlusion (38.6%). The location of the culprit coronary artery with the highest percentage is the left main and the right coronary artery (39%). No case in the study died, only 1 case had a stroke after the intervention (the patient recovered). There were no major complications associated with the procedure. The rate of complications of radial access is low, including 1 case of radial artery occlusion and 1 case of arteriovenous fistula. There were no cases of complications related to deformation of the slender glidesheath instrument or the interventional catheter.

Conclusion: The large-bore interventional catheter can be used with the support of 7Fr Glidesheath Slender for convenient and safe complex transradial coronary interventions.

Keywords: complex transradial coronary interventions, 7Fr Glidesheath Slender. 7Fr Guiding catheter

INTRODUCTION

Percutaneous coronary intervention is an effective method of treating coronary artery stenosis due to atherosclerosis. Coronary intervention using radial access has developed with many special advantages in reducing the risk of bleeding and has become the preferred choice when performing percutaneous coronary intervention [1] However, the small size of the radial artery is still perceived by many operators as one important limitation for the use of large-bore

Correspondence to: Dr. Huy The Nguyen. Cardiovascular Center, E Hospital, Hanoi, Vietnam.
Email: nguyenthehuy295@gmail.com

guiding catheters (>6 Fr) [2]. The Glidesheath Slender 7Fr Device (Terumo Inc, Japan) is a newly designed access opener that provides the same size as a standard 6Fr vascular access device but still provides Access to 7Fr interventional catheters. With this instrument, operators can perform interventional coronary artery lesions with a large-bore catheter (7F) through the radial artery to avoid having to transfer femoral arteries. A number of authors around the world have conducted studies using a large 7F catheter through the radial artery to intervene in complex coronary artery lesions with the support of the Glidesheath Slender vascular access device. 7F [3]. In Vietnam, there are no studies evaluating the effectiveness of this method on Vietnamese patients. Therefore, we conducted a study to evaluate " The results of using 7 French Glidesheath slender for complex transradial coronary interventions" to: feasibility and results of intervention for some complex coronary artery lesions using 7F radial catheter with the help of Glidesheath Slender 7F vascular access device. At the same time, learn some factors related to intervention outcomes in the group of patients mentioned above.

METHODS

Study population

From October 2020 to September 2021, we conducted the study on 44 patients with complex transradial coronary interventions in whom PCI using 7 French Glidesheath slender was performed at E hospital.

Criteria for patient selection

• Patients undergoing percutaneous coronary angiography have coronary artery lesions on angiogram that are complicated lesions that need to use interventional catheters of size 7F according to the interventionist's assessment: Leftmain lesions, bifurcation, calcified, chronic occlusive lesions.

Exclusion criteria

• There is an infection of the radial puncture site, a pre-existing loss of radial pulse.

• Severe medical condition (cardiogenic shock, kidney failure, contrast allergy, end stage cancer).

• The patient does not have enough information in the records, not enough time to follow up.

• The patient did not consent to participate in the study.

Study design

• A prospective interventional study without a control group

Data analysis and statistical method

• Baseline characteristics and procedural data were recorded propectively on standardized forms and entered into a camputerized database

• Recorded data were analyszed for all patients and results are expressed as proportion or mean ± SD

• Software used SPSS 20.0.

RESULTS

A total of 44 consecutive patients were included in the study and followed up for at least one month after the intervention. The mean age was 67,20 ± 9,12 years and 38 patients were male (86,4%). Common cardiovascular risk factor was hypertention (77,3%). Of the 44 cases, 13 patients (29,5%) had an acute coronary syndrome. Procedural characteristics and PCI complexity are summarized in Table II. Access was obtained through the right radial artery in 42 patients (95,5%) and previous homolateral transradial access was report in 19 (43,1%). The use of at least one 7 Fr guiding catheter was noted in all patients. Among coronary artery lesions, the highest rates were left main lesions (38.6%) and chronic total occlusion (38.6%). The location of the culprit coronary artery with the highest percentage is the

left main and the right coronary artery (39%). Various types of 7Fr guiding catheter were used in the study included: EBU (47,9%), AL 1.0 (31,3%), JL (12,5%) and JR (8,3%). Procedures requiring the use of a large-bore guiding catheter included in particalar unprotected LM disease in 17 patients (two stents implanted in 7 of 17 patients), CTO lesions in 17 patients (J-CTO ≥ 2 in 4 of 17 patients, antergrade in all CTO case). Rotablation for highly-calcified vessels in 10 patients, with the use of large -diameter burrs (>1.5). This calcified coronary case was depicted in Figs 1. Study and-point are listed in Table III. The rate of successful placement of the 7F Glidesheath slender was 97.7%. The successful intervention rate for target lesions is 90.9%. No case in the study died, only 1 case had a stroke after the intervention (the patient recovered). There were no major complications associated with the procedure. The rate of complications of radial access is low, including 1 case of radial artery occlusion and 1 case of arteriovenous fistula. There were no cases of complications related to deformation of the slender glidesheath instrument or the interventional catheter.

Table I. Baseline patient demographics

Characteristics		**Number (%) Mean ± SD (n=44)**
Age (yr)		67,20 ± 9,12
Sex	Men	38 (86,4)
	Women	6 (13,6)
Height (cm)		162,45 ± 5,81
Weight (kg)		61,82 ± 9,61
BMI (kg/m^2)	all	23,33 ± 2,81
	< 23	22(50)
	≥ 23	22(50)
Hypertention		34 (77,3)
Hyperlipidaemia		26 (59,1)
Diabetes		15 (34,1)
Active Smoking		26 (59,1)
Previous PCI		18 (40,9)
Previous CABG		1 (2,3)
Previous homolateral Transradial access		19 (43,1)
Acute coronary syndrome		13 (29,5)
Chornic coronary syndrome		31 (70,5)
Left ventricular ejection fraction		56,43 ± 12,91
Glomerular filtration rate		67,76 ± 23,37

Table II. Procedural characteristics and complexity of coronary intervnetions

	Number (%), mean ± SD (n=44)
Type of coronary lesion	
LM disease	17 (38,6)
Unprotected LM	17/17
Provisional stenting	9/17
Two stent technique	8/17
Bifurcation	2(4)
Provisional stenting	0/2
Two stent technique	2/2
CTO	17 (38,6)
J-CTO 0-1	13/17
J-CTO >=2	4/17
Tortuous and calcified vessels	4(9,1)
Rotablation	1(2,2)
Procedural Characteristics	
Right radial access	42(95,4)
Left radial access	2(4,6)

Number of 7Fr catheter used	
1	40(90,9)
2	4(9,1)
3	0
Type of 7Fr guiding catheter	
JL	6(12,5)
EBU	23(47,9)
JR	4(8,3)
AL	15(31.3)
Procedure duration (min)	65,8 ± 27,8
Total radiation dose (mGy)	559,5 ± 319,8
Total contrast volume (mL)	177,3 ± 62,6

Table III. Study endpoints

	Number (%), mean ± SD (n=44)
Placement of 7Fr guidesheath slender and 7Fr guiding catheter success	43 (97,7)
Procedural success	40 (90,9)
Death	0
Major bleeding	0
stroke	1 (2,2)
Local hematoma type I	2(4,4)
Major sheath kinking	0
Symptomatic radial spasm	1 (2,2)
Radial artery occlusion	1 (2,2)
Radial areteriovenous fistula	1 (2,2)

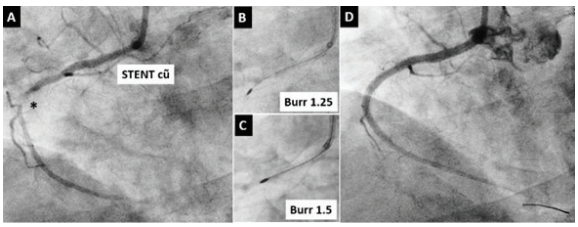


Fig 1. (A) severe and calcified restenosis lesion of the mid-right coronary artery. (B, C) Progressive rotational atherectomy with the use of 1.25 mm and 1.5 mm burr. (D) Final angiographic result after the placement of a long drug eluting stent

DISCUSSION

The mean age in the study was 67.20 ± 9.12. This result is similar to the study of Aminian and study of Meijers with mean age of 66 ± 11 and 68.8 ± 10.5 [4,5,6]. These are two studies using 7F guiding catheter for complex transradial coronary intervention. Subjects in our study are mainly men, accounting for 86.4%. The study of Nguyen Ba Hien and Nguyen Ngoc Quang on a group of Vietnamese patients also showed similar results, the diameter of the radial artery in men was larger than that of women (2.67 ± 0.08 compared to 2.52 ± 0,07, $p < 0.05$) [7]. The large mean radial vessel diameter is a factor that helps to reduce the rate of spasm and failure of radial intervention.

The 7Fr glidesheath slender is a recently developed thin-walled radial sheath. In combines an ID of 2.46 mm, which can accommodate any 7Fr guiding catheter, with an OD of 2.79 representing therey the thinnest 7 Fr sheath currently available on the market (Fig 2). This smaller OD results from a decrease in sheaht wall thickness from 0.20 to 0.12 mm and is a common feature of all slender sheaths produced by terumo.

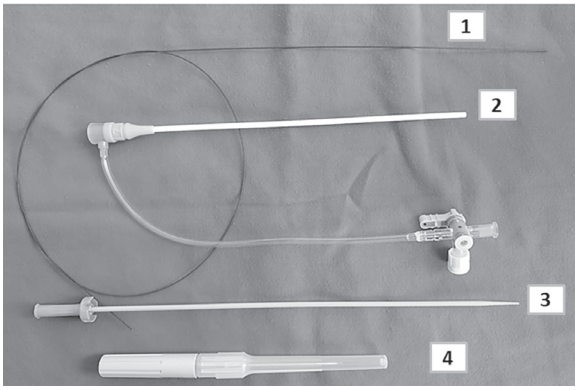


Fig 2. 7Fr Gildesheath slender device (Terumo Inc)

There was no difference in the entry technique of the glidesheath Slender 7F instrument compared with the standard 6F sheath instrument. We

performed a Sediger puncture and inserted the instrument in the same sequence as with a standard 6F sheath instrument. However, one thing to keep in mind when working with the Glidesheath Slender 7F kit is that this kit is longer in length than standard vascular sheath sets and the tube wall is also thinner, so be very careful. It is important to install and insert the catheter into the blood vessel to avoid breaking and bending the instrument (Fig 3). In our experience, in the case of a Glidesheath Slender 7F device being inserted into a vessel, angioplasty should be pre-dilated with a pre-existing catheter.

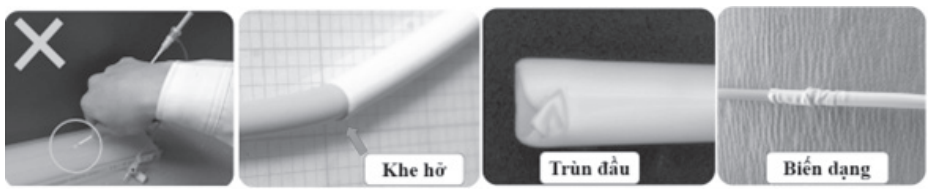


Fig 3. Major kinking of glidesheath slender

Regarding access, the Glidesheath Slender 7F can be used for both the right radial artery and the left radial artery. In our study, there were 2 cases where we used the 7F catheter through the left arm (4.5%) and the majority of the cases used the right radial artery (95.5%) (Table 3.6). In Aminian's study, the author used right rotation for 56 cases (93%) and left rotation for 8 cases (13%) [4]. Meijers' study used right rotation for 180 cases (93.3%) and left rotation for 13 cases (6.7%) [6]. In particular, in Gasparini's study, the distal part of the left radial artery was selected as the entrance for the 7F catheters through the Glidesheath Slender 7F instrument to intervene for 41 chronic occlusive coronary lesions [5]. This shows that the Glidesheath Slender 7F is very versatile and can be used for both the radial artery and the distal part of the radial artery on both sides.

In the study, the rate of Left-main lesions and chronic occlusive lesions accounted for the highest rate (38.6%). This result is similar to the study of Meijers et al (71.2%, n=194) and Aminian (58%, n=60). In addition to Left-main lesions and CTO, there are other complex lesions including: calcified lesions (9.1%), to (9.1%) and bifurcation (4) ,5%). As a result, 40 lesions were successfully intervened, accounting for 90.9%. In which, the success rate in the groups of left-main lesions, bifurcation, calcified lesions, tortuous vessels were 100%. In the group of chronic total occlusion lesions, there were 4 cases where we could not success intervention, so the success rate in the chronic occlusion group was 76.5%. The success rate of glidesheath Slender 7F and guding 7F were both 97.7%. There was only one case where the Glidesheath Slender 7F could not be placed and we had to switch to a target lesion intervention through the femoral artery.

We recorded 01 case of a patient with an ischemic stroke that appeared on the 1st day of intervention and then recovered. In the Aminian and Gasparini studies, no major cardiovascular events were recorded during the follow-up period. After the intervention all patients were examined and doppler ultrasound checked the radial artery. We recorded 2 cases of type 1 hematoma at the puncture site, accounting for 4.5%. There was no case of type 2 or type 3 hematoma. There was a case of ultrasound detecting radial artery catheterization after intervention, the patient was performed radial compression bandages for 24 hours, ultrasound still checked the current. venous catheterization. We continued to apply radial compression for 24 hours with second ultrasound to check that there

was no sign of arteriovenous patency. This patient was examined by ultrasound 1 month after the radial pulse was normal, there was no arteriovenous catheterization. One case did not capture the radial pulse after intervention, ultrasound showed radial artery occlusion. This is also the only patient who failed to insert the Slender 7F into the rotary circuit. Examination of the radial pulse after 1 month recorded 1 case of radial embolism, no cases of hematoma, arteriovenous catheterization or radial pseudoaneurysm.

CONCLUSION

We demonstrate here that the use of the 7Fr glidesheath slender for complex coronary intervention is feasible and associated with a high rate of procedural success and a low rate of vascular complications.

REFERENCES

1. Lee CW, Cho SC. The Transradial Approach for Coronary Intervention: More Comfort, Better Outcome. Korean Circ J. 2018;48(8):728-730.

2. Saito S, Ikei H, Hosokawa G, Tanaka S. Influence of the ratio between radial artery inner diameter and sheath outer diameter on radial artery flow after transradial coronary intervention. Catheterization and cardiovascular interventions : official journal of the Society for Cardiac Angiography & Interventions. Feb 1999;46(2):173-8.

3. Machaalany J, Abdelaal E, Bertrand O. Guide catheter selection for transradial Pci. Cardiac interventions today. 07/01 2013;

4. Aminian A, Iglesias JF, Van Mieghem C, et al. First prospective multicenter experience with the 7 French Glidesheath slender for complex transradial coronary interventions. Catheterization and cardiovascular interventions : official journal of the Society for Cardiac Angiography & Interventions. May 2017;89(6):1014-1020.

5. Gasparini GL, Garbo R, Gagnor A, Oreglia J, Mazzarotto P. First prospective multicentre experience with left distal transradial approach for coronary chronic total occlusion interventions using a 7 Fr Glidesheath Slender. EuroIntervention : journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology. May 20 2019;15(1):126-128.

6. Meijers TA, Aminian A, van Wely M, et al. Randomized Comparison Between Radial and Femoral Large-Bore Access for Complex Percutaneous Coronary Intervention. JACC Cardiovascular interventions. Jun 28 2021;14(12):1293-1303.

7. Nguyễn Bá Hiển NNQ. Đặc điểm hình thái hệ động mạch cấp máu bàn tay trên siêu âm Doppler mạch máu đối chiếu với kết quả chụp mạch số hóa xóa nền. . Luận văn thạc sỹ y học. 2019.

Aortic remodeling after thoracic endovascular aortic repair of acute type B aortic dissection

Hung Manh Pham [1,2], Tuan Minh Pham [1,2], Than Xuan Le [1]✉
Hieu Van Nguyen [1], Dat Van Le [1], Quang Ngoc Nguyen [1,2]
[1] Vietnam National Heart Institute, Bach Mai Hospital
[2] Hanoi Medical University

ABSTRACT

Objectives: Currently, thoracic Endovascular Aortic Repair (TEVAR) is increasingly used in the management of acute type B aortic dissection (TBAD). TEVAR has a role to help cover the entry tear and promote remodeling of aorta to reduce mortality. Complete false lumen thrombosis (FLT) is associated with better long-term outcome in these patients. Factors affecting aortic remodeling after TEVAR have received great attention from clinicians and are still unclear. Therefore, it is essential to evaluate aortic remodeling over time and investigate predictors of FLT.

Subjects and research methods: From January 1, 2017 to August 31, 2022. Including 93 patients diagnosed with acute complicated type B aortic dissection at Viet Nam National heart Institute - Bach Mai Hospital. Patient treated by TEVAR were Prospectively reviewed for statistical analysis. Aortic remodeling was evaluated based on the preoperative and before discharge, 1 month, 6 months and 12 months postoperative followed-up aortic CTA scan results. We analyzed the diameters of the descending thoracic aorta, true and false lumen diameter and the false lumen thrombosis status.

Results: A total of 93 patients with acute type B aortic dissection who underwent TEVAR during the study period were analyzed. The average age was 57,7 years (range, 31- 86 years). 84 patients (90,03%) were male. The landing zone was Zone 2 TEVAR in 80 patients (86,02%). At the segment aorta covered by Stent graft, the minimum diameter of the true lumen was significantly expanded, the maximum diameter of the false lumen tended to be reduced. However, the maximum descending thoracic artery diameter did not change significantly after the procedure, but only decreased significantly after 6 months of TEVAR, with $p < 0.05$. However, the segment of aorta uncovered by Stent graft, there was little change in the false lumen after TEVAR. The length of complete false luminal thrombosis increased over time (128.7 cm right after TEVAR and 132 cm after 12 months). Multivariate logistic regression showed that coverage aortic length >250 mm (Odds ratio: 3,78; p=0,008) was associated with significantly increased false lumen thrombosis ($p<0.05$).

Conclusions: TEVAR in patients with acute Stanford B aortic dissection promotes aortic remodeling including enlargement of the true lumen and the promotion of complete thrombosis of the false lumen. This remodeling occurred early after the intervention and continued after a follow-up period of up to 12 months. Coverage aortic length >250 mm was associated with significantly increased false lumen thrombosis. Studies with longer follow-up are needed to evaluate long-term aortic remodeling after TEVAR.

Keywords: Acute aortic dissection, TEVAR, Remodelling.

Correspondence to: Dr. Than Xuan Le. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam. Email: le.xuan.than.yhn@gmail.com

INTRODUCTION

Stanford B aortic dissection (TBAD) is a common pathology in acute aortic syndrome with a TBAD event rate worldwide of about 3/100,000 people/year [1]. Thoracic Endovascular Aortic Repair (TEVAR) is a procedure using a Stent graft system composed of a self-expanding stent covered by membrane (graft), which is inserted through the femoral artery, placed in the lumen of the aorta. The system helps to protect the pathological aortic wall from blood pressure, prevent rupture of the free aortic wall, widen the true lumen and increase blood supply to the compressed visceral vessels, thereby improving the mortality rate. TEVAR has replaced conventional open surgery as it is associated with lower morbidity and mortality and it is currently the first-line treatment option in acute TBAD. Current guidelines recommend TEVAR, covering the primary entry tear, for patients presenting with acute complicated type B aortic dissection (TBAD) and high risk uncomplicated TBAD. it is necessary to continue to monitor the progress, evaluate the results after the intervention with computed tomography (MSCT) of the aorta after the intervention at the time of 1 , 6 and 12 months to detect complications early, monitor progression, remodeling of the aorta, and should use the same assessment method at the same facility to facilitate comparison between results [2].

Aortic remodeling after TEVAR treatment of acute type B aortic dissection is an important process that reduces early events as well as aortic dilatation risks and rates of re-intervention. The process of aortic remodeling includes stabilization of the aortic wall to re-expand the true lumen and thrombosis of the false lumen. The process of aortic remodeling occurs both in the thoracic aorta, the part covered by the stent graft and the part that uncovered by the stent graft during the stabilization of the aortic wall. In the world, there have been a few studies evaluating aortic remodeling after TEVAR, but in Vietnam, there are no studies that fully evaluate the process of changing aortic structure after TEVAR, the factors that help promote aortic remodeling. The aim of this study was to evaluate thoracic aortic remodeling after TEVAR treatment for Stanford B aortic dissection.

MATERIALS AND METHODS

Objects and research methods

From January 2017 to August 2022, there were 93 patients diagnosed with acute Type B aortic dissection who underwent TEVAR at the Vietnam National Heart Institute - Bach Mai Hospital; The patients were collected clinical, laboratory data and followed up by MSCT at the time of admission, 1 month, 6 months and 12 months after TEVAR.

Diagnosis of type B aortic dissection is based on MSCT of the aorta with evidence of the presence of an entry tear and the formation of true and false lumens. Acute aortic dissection was defined as within the first 14 days after symptom onset and after that time was considered subacute or chronic.

Procedure

In this study, 93 Patients undergoing TEVAR treatment in the acute TBAD. The endograft-systems delivery performed via the femoral artery. In all patients, TEVAR procedure completed under the guidance of DSA imaging system. TEVAR were conducted under local anesthesia. We use of commercially available 3rd generation stent graft (Metronic's Valiant and Relay's Bolton). All Stent graft were oversized under 10% according to the manufacturer's IFU. The length of the proximal landing zones should be at least 20 mm.

Follow-up

Follow-up computed tomography angiography (CTA) was performed on the last day before discharge and 1 month, 6 months, 12 months and then yearly. Clinical data included comorbidities,

symptoms on admission, MSCT feature and indications for TEVAR as well as procedure detail, complications, mortality and re-interventions were recorded at every follow-up.

Imaging Analysis

Assessments of the aortic lument remodeling based on the aortic CTA scan results obtained at the time preoperatively and over the time. 3mensio imaging software is used to measure the parameters of aortic dimensions on MSCT. Evaluation of aortic reconstruction based on the following parameters: Maximum diameter of descending aorta, minimum diameter of true lumen, maximum diameter of false lumen, length of false lumen thrombosis. Complete false lumen thrombosis is defined as the absence of contrast enhancement in the false lumen.

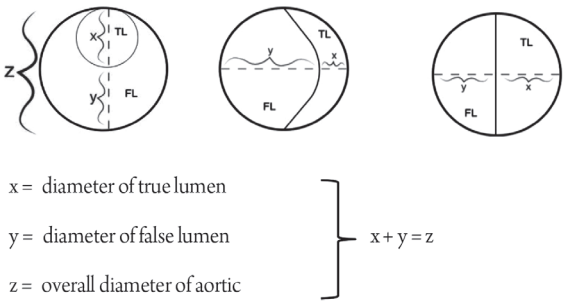


Figure 1. Luminal configurations of aortic dissection

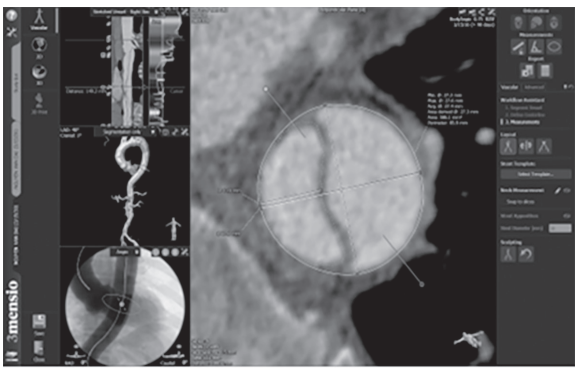


Figure 2. Measurements of the true lumen (TL) and false lumen (FL) diameter by 3mensio software (Patient code I71/100)

Statistical Analysis

Statistically analysis was performed using SPSS 22.0 and STATA 16.0 software. Continous variables were summarized as means ($\overline{X}$), standard deviations (SDs), Differences between the 2 groups were analyzed using χ^2 test, the difference is considered to be statistically significant when $p < 0,05$. Univariate and multivariate analyses based on logistic regression were used to assess the factors associated with aortic remodeling. Statistical results are expressed as percentage, mean ± standard deviation.

RESULT

Demographics and comorbidities of patients

A total of 93 patients with acute type B aortic dissection who underwent TEVAR during the study period were analyzed. Among these patients, 84(90.3%) were male. The mean age was 57,7 ± 11,1 (range, 31-86 years) and the proportion of patients with a history of hypertension were 76.3% with very severe pain symptoms (VAS 6.9 ± 1.2 points). Very high blood pressure on admission (systolic BP: 168.4 ± 33.0 mmHg, diastolic BP: 91.4 ± 15.3 mmHg). Multiple antihypertensive drugs were required (mean was 4 ± 1 drug).

Table 1. Demographics and comorbidities of patients with TBAD undergoing TEVAR.

Patient information (n=93)	**n (X ± SD)**
Age	57,7 ± 11,1
Male sex	84 (90.4)
Hypertension	71 (76.3)
Dyslipidemia	4 (4.3)
Diabetes mellitus	2 (21.5)
Stroke	3 (3.23)
Chronic renal insufficiency	6 (6.5)
VAS score	6,9
Systolic blood pressure	168,4 ± 33,0
Antihypertensive drug	4 ± 1

Preprocedural Imaging characteristics of patients

The length of entry tear in patient having Stanford B aortic dissection of 16.11 ± 11.98 mm. The true lumen was compressed with the minimum diameter of the true lumen on average 12.37 ± 5.58 mm. Maximum false lumen diameter was 17.92 ± 11.55 mm. The distance from entry tear to the subclavian artery was 35.61 ± 58.03 mm. Most patients need to extend the coverage to Zone 2 by covering the left subclavian artery, accounting for 88,17%.

All patients were assigned to conduct TEVAR due to complications in which rupture accounted for 17.20% with the rate of hemothorax accounted for 15.05%. Visceral ischemic complications account for 49.46% of patients and manifest in all visceral vessels, of which the highest rate is left renal artery ischemia at 21.51%. 9 patients performed carotid artery bypass surgery with anesthesia accounted for 9.67%,

Procedural details

A total of 93 patients were implanted Stent graft, including Valiant (Medtronic, United States) (n=62), Relay (Terumo, Japan). 82 (88,17%) patients were covered the left subclavian artery. 6 (6.45%) patients needed visceral artery intervention to revascularization. A total of 5 (5.3%) patients with complications of spinal cord ischemic received CSF drainage and subsequently recovered all 5 patients; 3 patients (3.2%) with ischemic stroke during in-hospital.

Aortic remodeling after TEVAR

Overall, 93 patients, only two patients were not available for postoperative CTA. During the imaging analysis using 3mensio software to visualize and measure during the follow-up period.

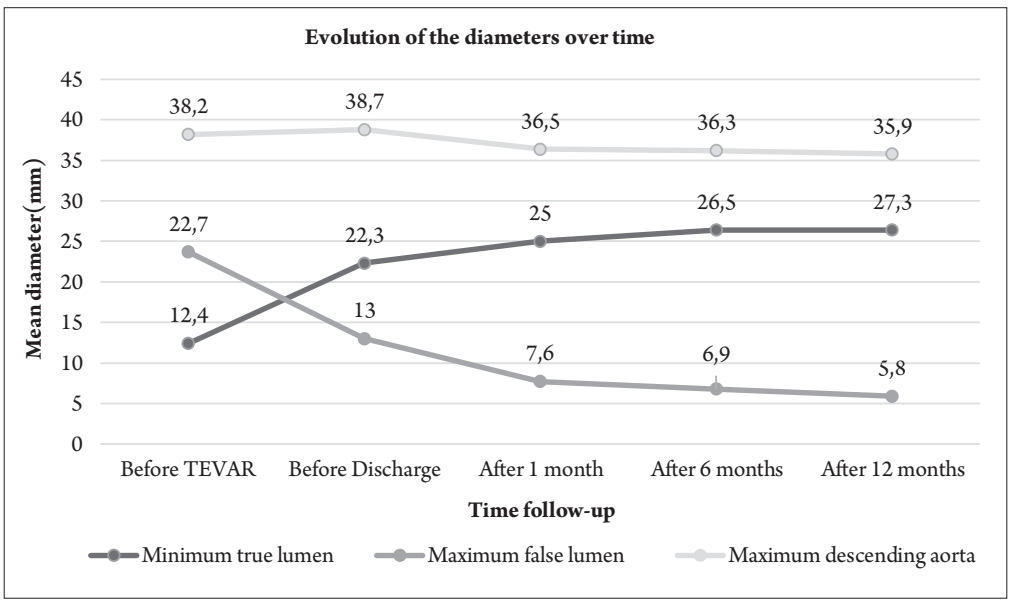


Figure 1. Evolution of descending aorta diameter over time

The average maximum descending thoracic aortic showed a slight increase from the preprocedural MSCT to the discharge time but then decreased by 1 month, 6 months leading to a significant decrease overtime. Then in the range of 6 months to 12 months, the decrease was not significant (p>0.05). The average minimum diameter of true lumen increased significantly immediately

after the procedure, after 1 month and after 6 months were statistically significant (p<0.05). From 6 months to 12 months, the minimum diameter of the true lumen still tended to increase but there is no statistical significance. The average maximum diameter of false lumen also decreased just after the procedure and significantly decreased over time from procedural time to 6 months. However, from 6 months to 12 months the reduction was not statistically significant. Particularly, the largest aortic diameter did not change significantly immediately after the procedure, but only really decreased with statistical significance starting from 1–6 months (p<0.05). While the abdominal aorta was not covered with stents, the change of aortic was not statistically significant.

Risk factor of Aortic remodeling

Complete thrombosis of false lumen along the treated aortic segment in 74 (81,3%) patients who had postprocedural CT scan. Logistic regression analysis was performed to identify the factors influencing complete false lumen thrombosis in the stented thoracic aorta. The length of the stent graft-covered segment > 250 mm increases the probability of complete false lumen thrombosis significantly (p=0.008). However, too large descending aorta diameter (>40 mm) and false lumen diameter > 22 mm had a lower incidence of complete false lumen thrombosis after TEVAR, although this association was not statistically significant (p>0.05).

Table 2. Factors influencing complete false lumen thrombosis

Risk factors	n (%)			OR	p
	Complete thrombosis false lumen (n=74)	Partial thrombosis false lumen (n=17)	N = 91		
Female	8 (10,8%)	2 (11,8%)	10 (11,0%)	0,84	0,815
Age	57,2 ± 10,3	59,6 ± 11,4	57,6 ± 11,2	1,03	0,311
Oversize ratio	8,2 ± 2,8	9,1 ± 3,6	8,6 ± 3,2	1,12	0,335
Tapper Stentgraft	48 (64,9%)	12 (70,6%)	60 (65,9%)	0,4	0,119
Patent SLA	11 (14,9%)	6 (35,3%)	17 (18,7%)	1,31	0,727
Carotid bypass surgery	6 (8,1%)	3 (17,6%)	9 (9,9%)	1,79	0,443
Diameter of ascending aortic greater 42mm	1(1,4%)	2(11,8%)	3(3,3%)	7,22	0,115
Diameter of descending aortic greater 40mm	14(18,9%)	6 (35,3%)	20 (22,0%)	0,92	0,872
Diameter of false lumen greater 22 mm	34 (45,9%)	8 (47,1%)	42 (46,2%)	0,87	0,778
Covered length greater 250 mm	**14 (18,9%)**	**11(64,7%)**	**25 (27,5%)**	**3,78**	**0,008**

Progression over time showed that the false lumen continued to be thrombus longer along the length of the aorta through the follow-up landmarks. The proportion of patients with complete false lumen thrombosis tends to increase gradually over time.

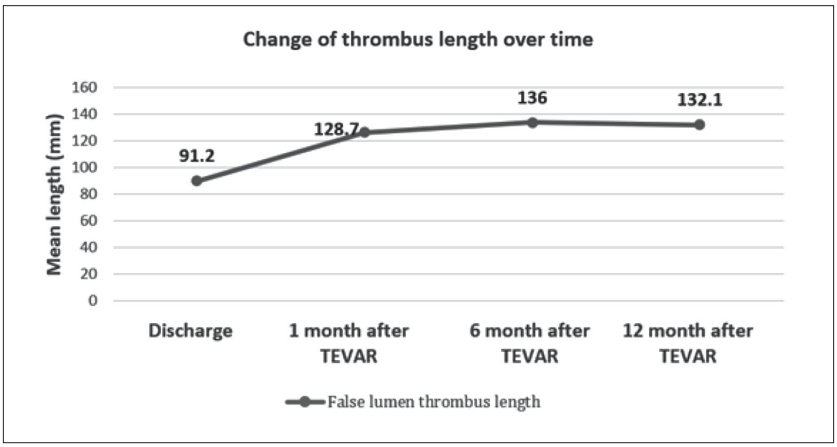


Figure 3. Change of false lumen thrombosis length over time

DISCUSSION

This model was based on the assumption that complete false lumen thrombosis after TEVAR. Change the anatomy of the aorta immediately after TEVAR in accordance with the principle and purpose when TEVAR in the treatment of aortic dissection. In theory, TEVAR coverage proximal entry tear, from which the blood flow does not pass through the tear into the false lumen, it helps to reduce the pressure in the false lumen, thereby they promote proximal thrombosis, reducing the rate of dilation of the aorta. At the same time, the true lumen is less pressured by the false lumen and expand. Besides, the Stentgraft thanks to the self-expansion of the stent system with radial force dilates the true lumen, increasing the perfusion of the blood vessels with ischemia due to the dynamic mechanism (the true lumen is strongly pressed) [3]. Thus, the concept of inducing false lumen thrombosis by sealing the aortic tear with Stent graft has the potential to reduce early and late complications of acute aortic dissection. Therefore, Aortic remodeling is considered to be associated with survival in patients with acute Stanford B aortic dissection.

Aortic remodeling over time

Computer tomography is an important investigation wich preferred in preparation for TEVAR intervention, Especially to estimate the size of the Stentgraft, deployment site and access sites all important consideration evaluated. MSCT is also important in the post-procedure follow-up of aortic remodeling.

Diameter change of descending thoracic aorta

In our study, after TEVAR, the diameter of true lumen increased and the diameter of false lumen significantly decreased immediately after the procedure, continued to increase slowly after 1 month, after 6 months. from 6 months to 12 months, the diameter of true lumen increased but not statistically significant. The maximum thoracic aortic diameter did not change significantly immediately after the procedure, the decrease was statistically significant from 1 month to 6 months ($p<0.05$). From 6 months to 12 months, the decrease wasn't statistically significant ($p>0.05$). Thus, Stent graft system has the role of protecting the aortic wall and the process of aortic remodeling changes immediately after the intervention, and tends to be stable after 6 months [4].

Diameter change of descending thoracic aorta

Analysis of the aortic image on MSCT over time showed the evolution of the remodeling process after TEVAR in the distal descending

aorta (the part not covered by the stent graft) and the abdominal aorta with re-entry. The re-entry still communicates with the false lumen, the true lumen, and the lateral branches that supply blood to the false lumen. Therefore, the distal segment is less protected by the stent graft system and the true lumen is still communicated by re-entry tears, so the pressure of the true lumen is still affected by blood pressure over time. may experience dilation of the false lumen as well as the true lumen, increasing the risk of future aortic dilatation-related complications. Similar to other studies in the world, it also shows that the process of aortic reconstruction after TEVAR changes mainly in the part covered with stent graft [5]. Thus, it can be concluded that after TEVAR helps to remodeling the aorta. It's mainly in the position of descending aorta covered stent graft, distal segment without covered stent graft and abdominal aorta without statistically significant changes. This is also the basis for solutions that need to increase the remodeling process of the distal segment below stent graft [6].

Progression of false lumen thrombosis

Complete false lumen thrombosis is important in predicting future events after TEVAR for acute TBAD because the outcome of false lumen thrombosis directly affects the rate of aortic re-intervention, the associated events such as dilation and rupture of the aorta. The characteristics in the process of false lumen thrombosis include 3 main types: the false lumen remains completely when there is blood flow throughout the false lumen in both arterial phase and late phase; partial false lumen thrombosis is defined when there is blood clot in the false lumen but there is still flow in the arterial as well as late phase, false lumen complete thrombosis when the blood clots in the whole false lumen and is no longer circulating at all. [7]. Monitoring the status of false lumen thrombosis in our study in the stent-graft coverage segment showed that length of complete false lumen along the stent increased over time. This result is similar to the studies of other authors from other sites[8]. At the same time, the length of the false lumen thrombosis increased gradually after TEVAR, after 1 month, and after 6, respectively, 91.2 mm; 128.7 mm; 136 mm. This result is similar to the conclusion in a systematic review of Benjamin, with 16 studies showing that after TEVAR treatment of Stanford B aortic dissection, there is a high rate of complete thrombosis of the false lumen to the stent graft site. from 80.6% to 90% after a follow-up period of 36 to 48 months. The rate of complete false lumen thrombosis to below the diaphragm site reaches 22% to 76.5% after one year of TEVAR[9].

Factors influencing complete false lumen thrombosis after TEVAR

In our study, 93 Patients, only 91 patients were available for the before discharge CTA follow-up analysis. The rate of complete false lumen thrombosis before discharge reached 81,3%. TEVAR promotes complete false lumen thrombosis due to two main mechanisms: first, the Stent graft covers the proximal entry tear, thereby cutting off the communication between the false lumen and the true lumen, and the second mechanism is due to spontaneous expansion. of the stent graft system will compress the separated endothelium. As a result, TEVAR reduces the size of the false lumen and promotes thrombosis of the false lumen, helping to remodeling and stabilize the aortic system[11]. The process of complete thrombosis of the false lumen depends on many factors, the most important of which is the length of the stent graft covering the aorta[12]. In patients after intervention, the existence of a false lumen is an important predictor of the risk of developing aortic dilatation later in life. Other causes include

Endoleak type 1 (Proximal seal failure with persistent flow through the primary entry tear and antegrade false lumen filling) so the false lumen is not thrombosed, increasing the risk of false lumen dilatation, the risk of requiring re-intervention. In our study, the length of the thrombosed false lumen gradually increased over time, and the number of patients with complete false lumen thrombosis also increased over time (Figure 3). The process of false lumen thrombosis is a factor that contributes to the stability of the aorta and reduces the complications of aortic dilatation as well as the risk of future re-intervention. In a retrospective study by Li of 59 patients with acute Stanford B aortic dissection, it was found that the more re-entry tears the patient had, the lower the probability of false lumen thrombosis. Dilatation of the descending aorta greater 50 mm reduces the degree of false lumen thrombosis. Anticoagulants and antiplatelet agents do not affect aortic remodeling in patients with acute Stanford B[13] aortic dissection. Recently, a number of studies have performed techniques to increase aortic remodeling and promote false lumen thrombosis by splicing the distal part of the stent graft with a bare metal self-expanding stent[14]complicated type B aortic dissection (TBAD. The mechanism of the bare stent system placed distal to the aorta has the role of widening the true lumen, pressing the endothelium towards the false lumen, thereby reducing the flow in the false lumen, and reducing the tearing force on the vessel wall. From this hemodynamic mechanism will lead to promote thrombosis in the false lumen.

CONCLUSION

This Study was performed in order to better define those patients that would most likely benefit from TEVAR following TBAD. TEVAR in patients with acute Stanford B aortic dissection promotes aortic remodeling including enlargement of the true lumen and the promotion of complete thrombosis of the false lumen. This remodeling occurred early after the intervention and continued after a follow-up period of up to 12 months. Coverage aortic length >250 mm was associated with significantly increased false lumen thrombosis. Studies with longer follow-up are needed to evaluate long-term aortic remodeling after TEVAR.

REFERENCES

1. Bossone E, Eagle KA. Epidemiology and management of aortic disease: aortic aneurysms and acute aortic syndromes. *Nat Rev Cardiol*. 2021;18(5):331-348. doi:10.1038/s41569-020-00472-6

2. Phạm Mạnh Hùng, Nguyễn Quang Tuấn, Nguyễn Thành Nhân. Khuyến cáo 2010 về các bệnh tim mạch và chuyển hóa, khuyến cáo của Hội tim mạch học Việt Nam về chẩn đoán và xử trí bệnh lý động mạch chủ ngực. *2010*. s

3. Wan Ab Naim WN, Sun Z, Liew YM, et al. Comparison of diametric and volumetric changes in Stanford type B aortic dissection patients in assessing aortic remodeling post-stent graft treatment. *Quant Imaging Med Surg*. 2021;11(5):1723-1736. doi:10.21037/qims-20-814

4. Pang H, Chen Y, He X, et al. Twelve-Month Computed Tomography Follow-Up after Thoracic Endovascular Repair for Acute Complicated Aortic Dissection. *Ann Vasc Surg*. 2021;71:444-450. doi:10.1016/j.avsg.2020.08.125

5. Wojciechowski J, Znaniecki L, Kaszubowski M, Rogowski J. Late Aortic Remodeling after Endovascular Repair of Complicated Type B Aortic Dissection-TEVAR Protects Only the Covered Segment of Thoracic Aorta. *Ann Vasc Surg*. 2019;55:148-156. doi:10.1016/j.avsg.2018.05.057
6. Vardhanabhuti V, Nicol E, Morgan-Hughes G, et al. Recommendations for accurate CT diagnosis of suspected acute aortic syndrome (AAS)--on behalf of the British Society of Cardiovascular Imaging (BSCI)/British Society of Cardiovascular CT (BSCCT). *Br J Radiol*. 2016;89(1061):20150705. doi:10.1259/bjr.20150705
7. Yuan Z, Li Y, Jin B, Wang J. Remodeling of Aortic Configuration and Abdominal Aortic Branch Perfusion After Endovascular Repair of Acute Type B Aortic Dissection: A Computed Tomographic Angiography Follow-Up. *Front Cardiovasc Med*. 2021;8:752849. doi:10.3389/fcvm.2021.752849
8. Bavaria JE, Brinkman WT, Hughes GC, et al. Outcomes of Thoracic Endovascular Aortic Repair in Acute Type B Aortic Dissection: Results From the Valiant United States Investigational Device Exemption Study. *Ann Thorac Surg*. 2015;100(3):802-808; discussion 808-809. doi:10.1016/j.athoracsur.2015.03.108
9. Patterson BO, Cobb RJ, Karthikesalingam A, et al. A Systematic Review of Aortic Remodeling After Endovascular Repair of Type B Aortic Dissection: Methods and Outcomes. *Ann Thorac Surg*. 2014;97(2):588-595. doi:10.1016/j.athoracsur.2013.07.128
10. Shen Y, Zhang S, Zhu G, et al. Risk factors of distal segment aortic enlargement after complicated type B aortic dissection. *J Interv Med*. 2019;2(4):154-159. doi:10.1016/j.jimed.2019.10.003
11. Lin Y, Dong S, Luo J, et al. Satisfactory Long-term Outcomes of Thoracic Endovascular Aortic Repair With a Bare Stent for Acute Complicated Type B Aortic Dissections. *J Endovasc Ther Off J Int Soc Endovasc Spec*. 2021;28(2):275-282. doi:10.1177/1526602820966991
12. Li D, Zheng T, Liu Z, Li Y, Yuan D, Fan Y. Influence of Distal Re-entry Tears on False Lumen Thrombosis After Thoracic Endovascular Aortic Repair in Type B Aortic Dissection Patients: A Computational Fluid Dynamics Simulation. *Cardiovasc Eng Technol*. 2021;12(4):426-437. doi:10.1007/s13239-021-00532-z
13. Chang H, Rockman CB, Cayne NS, et al. Anticoagulation and antiplatelet medications do not affect aortic remodeling after thoracic endovascular aortic repair for type B aortic dissection. *J Vasc Surg*. 2021;74(6):1833-1842.e1. doi:10.1016/j.jvs.2021.05.059
14. Lombardi JV, Gleason TG, Panneton JM, et al. STABLE II clinical trial on endovascular treatment of acute, complicated type B aortic dissection with a composite device design. *J Vasc Surg*. 2020;71(4):1077-1087.e2. doi:10.1016/j.jvs.2019.06.189
15. Mesar T, Alie-Cusson FS, Rathore A, Dexter DJ, Stokes GK, Panneton JM. A more proximal landing zone is preferred for thoracic endovascular repair of acute type B aortic dissections. *J Vasc Surg*. 2022;75(1):38-46. doi:10.1016/j.jvs.2021.06.036

Fenestrated TEVAR in acute type B thoracic aortic dissection: Experience at Vietnam National Heart Institute

Tuan Minh Pham[1,2]✉, Than Xuan Le[1], Quan Hong Dao[3]
Dat Van Le[1], Quang Ngoc Nguyen[1,2], Hung Manh Pham[1,2]
[1] Vietnam National Heart Institute, Bach Mai Hospital
[2] Hanoi Medical University
[3] Ninh Binh General Hospital

ABSTRACT:

Background: The distance from the left subclavian artery (LSA) to the entry tear may create challenges for endovascular repair technique in type B thoracic aortic dissection. A modified technique, fenestrated stent grafting, to extend the proximal landing zone could be effective in some typical cases.

Method: From January 2020 to May 2021, 21 patients underwent fenestrated thoracic endovascular aortic repair (f-TEVAR). The pathologies including descending aortic intramural haemorrhage (4 cases), penetrating aortic ulcers (3 cases) and acute type B thoracic aortic dissection (TBAD) (14 cases) with shortness of proximal landing zone. Medical history, medical records, computed tomography scan and angiograms were reviewed in detail. All patients were underwent 3 months follow medical check up.

Result: The average age of patients was 61.4 years (range 45 – 79) and 16 of them were man. The average proximal landing zone was measured 14.67 mm (range 12 – 17) and the distance between left common carotid artery to LSCA was 8.2 mm (range 6 – 11). 21 fenestrated stentgrafts (STG) were deployed (12 Medtronic Valiant STGs and 9 Relay STGs). Successful rate of endovascular technique was 95.3% with no significant longer intervention duration. We misplaced the fenstrated hole after deployment in one case, but chimney technique was performed alternatively. No endoleak was revealed after 3 months CT scan check. None of patient developed stroke, spinal cord injury developed (SCI) in 1 case, postoperatively. The procedure-associated SCI rate was 4.7%.

Conclusion: The successful rate of f-TEVAR technique was 95.3% and maintaining good LSA blood flow. The incidence of stroke was none and postoperative SCI was 4.7% and recovered. f-TEVAR can be safely applied in acute TBAD and descending aortic lesions with shortness of proximal landing zone.

INTRODUCTION

Over 2 decades, thoracic endovascular aortic repair (TEVAR) has gradually become the alternative therapy for type B thoracic aortic diseases management,[1-2] including acute aortic syndromes. This procedure provided advantages: less invasive, quick recovery time and less complications in compare with open surgery, especially in aortic dissection. Although technical skill of physicians and development of devices are always improved to manage complicated cases, there still remains some difficulties due to anatomical problem such as angulation of the aorta, dilatation of aortic diameter, totuouness of the aorta, shortness of proximal landing zone.[1-3]

Correspondence to: Dr. Tuan Minh Pham. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam; Department of Cardiology, Hanoi Medical University, Hanoi, Vietnam. Email: ngminhtuan82@yahoo.com

Various of methods were invented to manage these problems: Chimney technique, hybrid approach, fenestrated therapy. Those methods were considered carefully depend on lesions of the oarta, however, some limitations were still revealed, for example: invasive technique, prolong recovery time, more preparation time consuming, other complications (stroke, spinal cord ischemia, paraplegia).[3-4] Those are mortal challenges in acute thoracic aortic diseases.

The aims of study were to access the aptitude of acute TBAD with shortness of proximal landing zone management using fenestrated TEVAR and the outcomes after 3 months follow up of these patients.

PATIENTS AND METHODS:

The median patients' age was 61.4, ranging from 45 to 70 years old, 28.6% were female and 71.4% were male. 21 patients were referred to Vietnam National Heart Institute, including 3 cases with dignosis of acute type B aortic dissection (TBAD), 4 cases with descending intramural haemorrhage (IMH) and 3 cases with penetrating aortic ulcer (PAU). 85.7 percent of them has a history of hypertension but uncontrol anti-hypertensive therapy, and 14.3 percent without hypertension. All of them was hospitalized urgently due to complaint of severe chest and back pain. Percentage of mild renal failure was 19% and diabetes mellitus was 23.8%. Computed tomography showed acute lesions of the descending aorta. The inclusion/exclusion criteria for endograft treatment of thoracic aortic pathology have been considered in detail. Careful investigation of the preoperative imaging was crucial in planning these procedures and anticipating the potential difficulties. Shortness of proximal landing zone was found, distributed from 12 mm to 17 mm, 14.6 mm in average. It was the most challenging in TEVAR technique according to Guideline of Thoracic aortic disease management, high risk of type IA proximal endoleak.

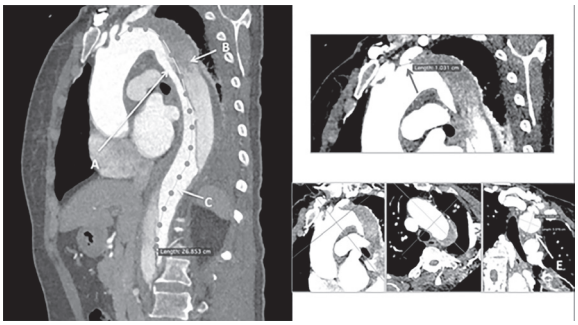


Figure 1. Acute stanford B aortic dissection.
A: True lumen. B: False lumen. C: Aortic lesion length. D: LSA diameter. E: Aortic diameter in proximal landing zone.

Distances between LCCA and LSA were measured meticulously, 8.2 mm in avegare (range 6 – 11 mm). This was the most important parameter to make compatible fenestrated hole in the stent graft body. Base on the characteristic of the aortic lesions, we developed the devices to obtain more proximal landing zone to get effective sealing according these steps below. The devices were Medtronic Inc. Valiant and Relay thoracic stent grafts, approved by the US Food and Drug Administration.

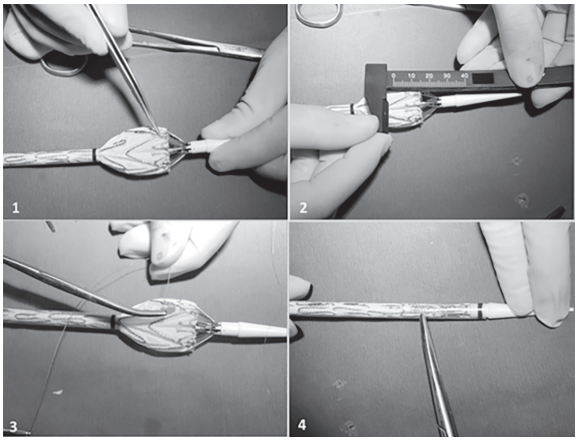


Figure 2. Steps to make compatible fenestrated hole in the stent graft body.
1: expose the STG body and marked the distance.
2: measure and make appropriate fenestrated hole to LSA.

3: mark the fenestrated hole using Lunderquist guidewire tip.
4: withdraw STG into the deliver, fenestrated hole was recignized by the Lunderquist guidewire.

Fenestrated hole design: the first step was exposing the upper side of the stent graft's body, find the marker located on the stent that appropriate to the LSA. Second step was measuring the distance between the edge of the graft to the planning hole (due to individual distance from the LCCA to LSA) on the line with the marker and made the fenestrated hole, the diameter of the hole was belong to the individual LSA of each patient. Third step: cut the tip of Lunderquist guidewire and suturing around the hole, this step was to recognize the hole location under angiogram. Last step is to withdraw the stent graft into the deliver, this step needed to be gentle to not destroy the structure of the stent graft.

Routine femoral accessment was performed, pig-tail sonde was used to ensure true lumen. Device was deployed as regular progress. Before deploying the stent graft, its was essential to locate the fenestrated hole adaptibly to the LSA ostium under angioghraphy. A 6F sheath was cannulated via radial artery access and a Terumo guidewire was advanced along the artery to enter the fenestrated hole. An optimal size self-expanding covered-stent was then deployed in plan. The LSA blood flow was checked after all deployments.

After deployment of stent graft, angiography was checked in every case. No incidence of perioperative endoleak was reported. Duration of intervention time was no statistical significant longer than regular progress (averagely 68 mins ± 12 mins vs 55 mins ± 7 mins). No injury of femoral artery was detected. Incidence of stroke was none, spinal cord injury developed (SCI) in 1 case, postoperatively. This patient was a 79 year-old-male obesity patient with no renal failure but under diabetes mellitus treatment. He was under very strict monitor postoperavively, because of high risk patient, and paraplegia was detected 3 hours after intervention. Spinal drainage was performed immidiately to relief spinal cord compression. He was recovered completely after 2 days.

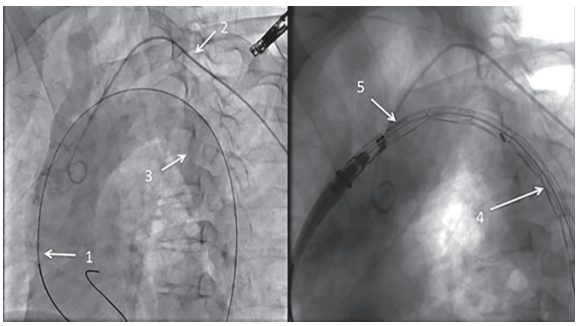


Figure 3. Peri-operative images of F-TEVAR
1: super stiff-wire inserted via femoral artery.
2: pig-tail sonde via radial artery into LSA to access fenestrated hole on STG body after deployment.
3: aortic true lumen.
4: stent-graft was delivered via femoral artery.
5: fenestrated hole on STG body was marked by Lunderquist guidewire tip, compatible to LSA ostium.

All the patients were under individualized optimal medical therapy. After 3 months, all of them were under programmed follow-up examinations. Regular blood test, multi-slice computed tomography were conducted. Total closed of entry tear with TBAD and IMH, no type IA endoleak was found in all patients. The patient with spinal cord injury had no more paraplegia and had no more complaint.

All the patients signed consent forms for the use of these devices and agreed to participate in the surveillance protocols after deployment of the devices.

RESULT AND DISSCUSION

In the recent years, TEVAR has become the alternative therapy for type B thoracic aortic diseases management, due to some obvious advantages in

patients with suitable aortic anatomy. In compare with open surgery using sternotomy, deep hypothermia and cardioplegia, endovascular therapy is less invasive, less complications and decrease the duration of recovery time. With the development of physical technical skill and, device generations, endovascular therapy becomes the first choice for TBAD patients with appropriate aortic anatony.[1-3]

However, not every case with TBAD is favourable anatomy for endovascoular therapy. Especially, in clinical work, the most difficult is shortness of proximal landing zone (distance between LSA ostium to the entry tear position, at least 20 mm), whereas this is an essential demand to achieve safe procedure. Moreover, maintaining the LSA blood flow play an important role to decrease the post operative complications, such as cerebral ischemia, spinal cord injury.[4,5]

In our study, the average distance of proximal landing zone was distributed from 12 mm to 17 mm, 14.6 mm, shorter than least demanding for safe intervention (20 mm at least).

To overcome this problem, several techniques were invented to extend the landing zone, such as aortic arch replacement + TEVAR (elephant trunk + TEVAR), chimney-TEVAR (Ch-TEVAR), debranching-TEVAR, SCA bypass + TEVAR, and fenestrated TEVAR. After careful accessment of aortic image and fatal complication risk of the aortic lesions, urgent interventions demanding, we decided to perform fenestrated TEVAR. The aim were not only to close the entry tear but also maintaining the LSA blood flow and achieve optimal landing zone of proximal side. Futhermore, obtaining safe procedure was the first priority.

In the very first part of intervention era, with this kind of lesions, the interventionists performed TEVAR covering the ostium of LSA to get enough proximal landing zone. However the brain ischemia and SCI rate of of these patients were remaied high. Then maintaining the LSA blood flow of these patients became the big challenge for interventionist.[3]

Classic elephant trunk technique (CET) or frozen elephant trunk (FET) technique became consolidated options to treat complex aortic arch lesions. They could be peformed both in single hybrid or multiple stage endovascular approach. However, the preparation time and duration time of these techniques were remarkable. Futhermore, during these operations, the heart was temporarily stopped by cardioplegia solution, the patient was placed on heart lung machine to maintain the blood flow to the heart and other organs, especially selective blood flow to the brain. These surgery was invasive, time consuming and long recovery time.[6-8]

Chimney-TEVAR (ch-TEVAR) is a one of the highest stratery in the development of intervention method for complicated TBAD, a self-expandable covered-stent was placed into the branch vessel and the proximal side was into the aortic with the proximal of the stent graft. This technique allowed more place for the proximal stent graft as demanding while maintain the blood flow of LSA. However, the limitations of this ch-TEVAR technique include loss of wall apposition with resultant gutters increasing the possibility of type IA endoleaks. Furthermore, the covered-stents may become kinked, compressed, or even occluded.[6-9]

Debranching TEVAR or RSA-LSA bypass + TEVAR is a hybrid therapy. Nevertheless, in urgent cases, time-consuming of preparation for surgery may cause unexpected complications.

Custom-made stent-graft may become the optimal choice for the difficulty of aortic anatomy. But, it cost a big amount of finance, besides it may spend long time for manufacturing, not allowed in emergency cases.

In these emergency cases, especially, aortic

impending rupture or rupture cases, indications and interventions were immediately needed. There were not much time for equipments preparation. f-TEVAR can be a good solution in acute TBAD patients with shortness of proximal landing zone. This technique could be quickly approach as simple TEVAR, with high precision rate, and short duration time. On the other hand, F-TEVAR is the less of the gutters created by chimney grafts, lessening the likelihood of type IA endoleaks and decrease the radical force to the aortic wall, may help lessing retrograde dissection or rupture incidencce. The most important point of this technique: a distance of 6-8 mm between left common carotid artery to LAS ostium is essential to achieve enough placement of proximal stent graft, and Lunderquist guidewire tip as the marker to identify the fenestrated hole. After deploying stent graft, advanced the terumo wire through the hole and deploy the covered-stent.

There were several sastifactory results form some cohort study in patients with difficult thoracic and abdominal aortic diseases. In this technique, covered-stent was not parallely advangced into aortic lumen, as in chimney technique, lessing incidence of type IA endoleak, retrograde dissection or rupture, advoid covered-stent related complications. Beside, fenestrated duration time spent 15 mins in maximum, then this strategy can be proceeded in some emergency descending thoracic aortic syndromes.

In our study, successful rate of technique was 95.3 percent. Due to precise plans from the beginning, there were no complication peri-operatively. There was no type I endoleak or rupture. The access vessels were safe. The duration of intervention time was 58 mins ± 12 mins, no significantly longer than regular procedure.

We routinely checked post-operative angiography for every patients. There were no deveploment of type I endoleak, and the LSA blood flows were good remained. One patients was fail to deploy the fanestrated hole in the precise position of the LSA (4.7%). However, we performed chimney TEVAR instead. After considering all the steps of the intervention, the reasons of this mistake might due to the big diameter of the proximal aorta (38 mm in diameter), blood pressure control was not low enough for deployment, the movement of the patient or the structure of the stent graft was changed after fenestrated hole design step. This case was one of the very first case of the study though, there was no more mistke repeated in other cases.

There was no post-operative stroke but 1 patient developed paraplegia after 1 days of intervention (rate 4.7%.). This complication was due to spinal cord injury. The mechanism of this complication was not clear investigated. Some hypothesizes for immediate SCI was related to acute ischemia of the spinal cord secondary to coverage of a large segment of intercostal vessels and other collaterals to the spinal cord blood supply. There were some risks factors listed for spinal cord injury, such as obesity, peri-operative blood loss, vascular embolization.

In our study, the patient with SCI was an obesity 79 year-old-male with no renal failure but under diabetes mellitus treatment. He was under very strict monitor postoperavively, because of high risk patient, and paraplegia was detected 1 day after intervention. Spinal drainage was performed immidiately to relief spinal cord compression. He was recovered completely after 2 days.

After 3 months check, all the patients underwent medical check up as the protocol of the study, including regular blood test and aortic MSCT investigation. There was no development of endoleak in these patients. There was no neurologic deficit recorded, stroke or late SCI was not reported in our study. Patient with complication was totally

recovered and had no further problem.

In our study, from January 2020 to May 2021, only 21 acute aotic symdrome patients participated. This was a small quantity of acute TBAD patients in our TBAD patients under endovascular therapy. And 3 months post operative aortic MSCT investigation was not a long time of follow up progress. Our proposal is collecting more patients and further aortic imaging investigation for this patients in the future.

Futher more, in the future work, in clinical pratice, we are planning to perform fenestrated TEVAR not only for TBAD patients with shortness of proximal landing zone, but also for appropriate patients with TBAD patients that retrograde dissection to the aortic arch if surgical therapy is not recommended.

CONCLUSION

Fenestrated TEVAR in emergency proximal short landing zone TBAD management is a difficult and accuracy demanding procedure. This technique can be conducted in a well equiped centre with experienced interventionists. It can be quickly performed, responding urgent intervention in acute stanford B thoracic aortic diseases with shortness of proximal landing zone. Further study is needed to achive more information of this strategy.

REFERENCE

1. Konstantinos G. Moulakakis, "Management of complicated and uncomplicated acute type B dissection. A systematic review and meta-analysis", Annals of cardiothoracic surgery, Vol 3, No 3 May 2014.
2. E. Kieffer,"Dissection of the descending thoracic aorta," inVas- cular Surgery, R. B. Rutherford, Ed., pp. 1326–1345, WB Saun- ders, Philadelphia, Pa, USA, 5th edition, 2000.
3. B. Zha, G. Xu, H. Zhu et al., "Endovascular repair of type B aortic dissection with the restrictive bare stent technique: morphologic changes, technique details, and outcomes, Therapeutics and Clinical Risk Management 2018:14.
4. T. Ohrlander, B. Sonesson, K. Ivancev et al., "The Chimney Graft: A Technique for Preserving or Rescuing Aortic Branch Vessels in Stent-Graft Sealing Zones", J ENDOVASC THER 2008;15:427–432.
5. J. Zhu, X. Dai, P. Noiniyom et al., "Fenestrated Thoracic Endovascular Aortic Repair Using Physician-Modified Stent Grafts (PMSGs) in Zone 0 and Zone 1 for Aortic Arch Diseases", Cardiovasc Intervent Radiol, 2018.
6. K. Kansagra, J. Kang, M. C. Taon et al., "Advanced endografting techniques: snorkels, chimneys, periscopes, fenestrations, and branched endografts", Cardiovasc Diagn Ther 2018;8(Suppl 1):S175-S183.
7. R. Coscas, H. Kobeiter, P. Desgranges et al.,, "Technical aspects, current indications, and results of chimney grafts for juxtarenal aortic aneurysms", Journal of Vascular Surgery, Volume 53, Number 6, Jun 2011.
8. K. P. Donas, J. T. Lee, M. Lachat, "Collected World Experience About the Performance of the Snorkel/Chimney Endovascular Technique in the Treatment of Complex Aortic Pathologies - The PERICLES Registry", Annals of Surgery, Vol 262, Number 3, September 2015.
9. I. N. Roy, M. Gharib, S. Zerwes, "Anatomical Applicability of Endovascular Aneurysm Sealing Techniques in a Consecutive Cohort of Fenestrated Endovascular Aneurysm Repairs", Journal of Endovascular Therapy 00(0), 2017.

Minimally invasive video-assisted mitral valve replacement via right mini-thoracotomy

Dat Quoc Pham✉, Hoan Thi Duong, Do Dinh Ta, Duyen Thi Nguyen, Hieu Cong Vu
Tung Thanh Le, Tuong Manh Luong, Uyen Thi To Dinh, Hung Duc Duong
Vietnam National Heart Institute, Bach Mai Hospital

ABSTRACT

Background: Minimally invasive mitral valve surgery (mini-MVS) has become routine in some institutions. However, the data of mini-MVS in rheumatic disease is very limited. We conducted a study to evaluate the safety and efficacy of minimally invasive mitral valve replacement (MIMVR) for treating rheumatic mitral valve disease in Bach Mai hospital.

Methods: From January 2018 - Deccembre 2020, 80 patients with rheumatic mitral valve disease underwent mitral valve replacement via right minithoracotomy at Vietnam National Heart Institute. We analyzed early postoperative outcomes, including 30-day mortality.

Results: Our cohort included 22 (27.5%) males and 58 (72.5%), with mean age of 49.9 ± 9.5 years, left ventricular ejection fraction of 64.5 ± 7.3%, and New York Heart Association functional classification of 2.55 ± 0.53. Mean cardiopulmonary bypass time of 93.8 ± 17.9 min, and cross-clamp time of 61.9 ± 14.6 min. Mean mechanical ventilation time was 15.8 ± 24.7 hours, intensive care unit length of stay was 54.5 ± 79.9 hours, and hospital length of stay was 10.5 ± 4.7 days. No conversion to sternotomy was required and no cerebrovascular accidents occurred. Groin seroma occurred in 1 (4.4%) patient, haemothorax and pneumothorax in 7 (8.8%). 30-day mortality was 1.3%. Pre-discharge echocardiography revealed no residual gradient in all patients.

Conclusions: Preliminary results for our minimally invasive mitral valve replacement in rheumatic diseases demonstrate early safety, with acceptable operative times and outcomes.

Keywords: minimally invasive, mitral valve replacement, continuous suture technique, rheumatic heart disease.

I. INTRODUTION

Rheumatic heart disease (RHD) remains prevalent in developing countries [1]. The mitral valve is most frequently involved in RHD, with characteristics of stenosis, regurgitation or mixed lesions, which often demand valve replacement in most cases [2]. Traditional mitral valve surgery via a median sternotomy is safe and effective, but it results in a high degree of trauma and a long incision [3]. Since the success of the first video-assisted mitral valve repair performed by Carpentier et al. in February of 1996 [4], minimally invasive mitral valve surgery (mini-MVS) has become increasingly popular in many institutions. Following excellent reported results, mini-MVS has become a standard approach at some centers in the world [5]. Recent meta-analyses have demontrated cardiopulmonary bypass (CPB) and cross-clamp times are typically longer in minimally invasive cases but there is no

Correspondence to: Dr. Dat Quoc Pham. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam. Email: dr.phamquocdat@gmail.com

significant difference in mortality between minimally invasive and conventional approaches [3],[6],[7]. However, due to the low prevalence of rheumatic valve disease in the Western world, the data of mini-MVS in rheumatic disease is very limited [5]. We conducted a study to describe our technique and evaluate the safety and efficacy of minimally invasive mitral valve replacement (MIMVR) for treating rheumatic mitral valve disease at the Vietnam National Heart Institute, Bach mai hospital.

II. METHODS

1. Materials and study setting

This study is a prospective case series of 80 consecutive patients suffering rheumatic mitral valve disease treated by valve replacement through a right mini-thoracotomy from January 2018 to Decembre 2020 at the Vietnam National Heart Institute, Bach Mai hospital. The aim of this study is to describe our technique and evaluate the feasibility, efficacy, early outcomes including 30-day mortality within this group. Indications for mitral valve surgery were based on the recommendations of the American Heart Association/American College of Cardiology on the management of heart valve disease [8]. Pre-, intra- and postoperative data were prospectively entered into a patient data management system for analysis. We included all patients with rheumatic mitral valve disease and an indication for mitral valve replacement. Patients with mitral valve disease which has not caused by rheumatism, those suffering additional aortic valve disease, or patients with severe peripheral artery disease precluding femoral cannulation for CPB were excluded.

2. Surgical technique

All cases were conducted under general anesthesia with a double lumen endotracheal tube. In the supine position, a roll is placed under the right scapula to elevate the right hemi-thorax by 30-45o, and both arms tucked. The femoral artery and vein are dissected in preparation for cannulation with a 2-3cm oblique right groin incision. A 4-6 cm right lateral thoracotomy is used to enter the right hemithorax via the fourth intercostal space (ICS). A 5mm endoscope is inserted through a trocar in the 3rd ICS at the anterior axillary line to assist in visualization. We use a mini-thoracic retractor (Aesculap Valve XS instruments, Center Valley, PA, USA), taking care to spread the ribs gradually to prevent fracture. The femoral artery cannula is inserted directly into the common femoral artery. A single multi-stage venous cannula is typically utilized for isolated mitral valve surgery and inserted using the Seldinger technique with the tip of cannula advanced to the superior vein cava (SVC) under transesophageal echocardiography (TEE) guidance. If venous drainage is inadequate or the repairment of the tricuspid valve is required, an additional venous cannula may be placed percutaneously into the SVC from internal jugular vein, again using the Seldinger technique. After femoral arterial and venous cannulation, cannulas are secured and CPB initiated (Figure 1).

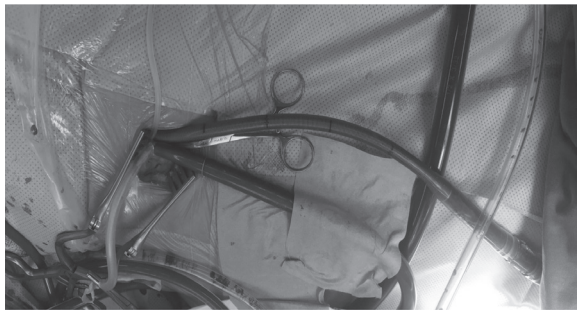


Figure 1. Femoral arterial and venous cannulation arrangement

CPB is initiated with vacuum-assisted venous drainage and body temperature maintained at approximately 34°C. The pericardium is opened parallel to and about 1-1.5cm below the anterior

chest wall, from the distal ascending aorta to the diaphragm. The inferior edge of the pericardium is secured to the right lateral thorax with stay sutures passed through a 0.5-1cm incision at the mid-axillary line in the 4th ICS. A left ventricular vent and Chitwood aortic clamp (Aesculap Valve XS instruments, Center Valley, PA, USA) are also inserted via this port site (Figure 2).

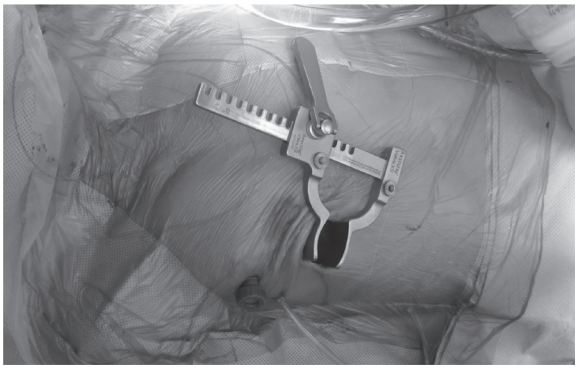


Figure 2. Right lateral mini-thoracotomy at 4th intercostal space

A long cardioplegia needle (Livanova, London United Kingdom) is utilized to deliver warm blood cardiopledgia directly into aortic root and repeated every 15-20 minutes. The mitral valve is accessed through a vertical left atriotomy and exposed by a left atrial retractor, inserted and secured at the 3-4th ICS in a right parasternal position, under video guidance to prevent injuring the right internal thoracic artery. After assessing the mitral valve and confirming the need for replacement, the leaflets are excised in routine fashion. We use two techniques for mitral valve replacement:

Continuous suture technique: indication for mechanical valve replacement with valve annulus which is not too small, fragile or severe calcification. Two 2-0 ethibond sutures are tied together at their ends to create a longer double armed suture. The first annular suture incorporating the valve sewing ring is started at the 6 o'clock position of the mitral annulus. We continue backhand over-and-over suturing toward the 8-9 o'clock position (passing the needle from the annulus to the sewing ring) with prosthetic valve placed into left ventricle and then continue to the 12 o'clock position using a forehand technique (prosthesis valve was taken out of left ventricle). The second suture arm is sewn similarly in a continuous backhand counter-clockwise direction toward the 3 o'clock position, then forehand until reaching 12 o'clock, and the two suture ends tied to secure the valve for completed mitral valve replacement (Figure 3 - right).

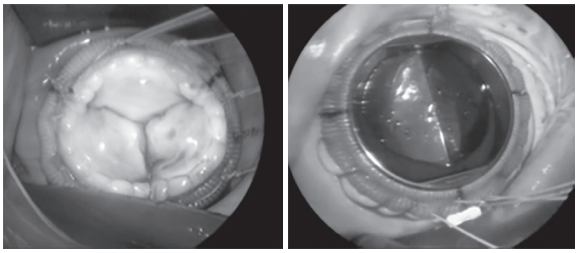


Figure 3. Technique for continuous suture (right) and interrupted suture (left) mitral valve replacement

Table 1. General characteristics and history of patients

Variable	**Value**
Age	49.9 ± 9.5 (min: 31; max: 68)
Male Sex	22 (27.5%)
Body Mass Index	20.8 ± 2.7 (min:15.2; max:29.3)
History	
Rheumatic history	43 (53.8%)
Diabetes mellitus	7 (8.8%)
Chronic obstructive pulmonary disease	4 (5.0%)
Hypertension	11 (13.8%)
Prior cerebrovascular accident	11 (13.8%)
Prior mitral procedure	21 (26.3%)

Mean LVEF of 64.5 ± 7.3%. Only two patients had a LVEF < 50%. Mean of New York Heart Association (NYHA) functional class was 2.6 ± 0.5; with 43 (53.8%) patients suffering NYHA class III-IV symptoms. Rheumatic lesions of the mitral valve were observed in all patients, of which 13 (14.6%) patients had severe regurgitation, 29 (36.3%) patient had severe stenosis and 38 (47.4%) patients had mixed lesions. Severe regurgitation tricuspid valve was present in 14 (17.5%) patients. The average diameter of left atrium was 53.2 ± 7.6 mm, including 55 (68.8%) patients with left atrial diameters more than 50 mm. Mean of pulmonary artery systolic pressure was 48.4 ± 15.2 mmHg (range 25 – 95mmHg). Atrial fibrillation was present in 52 (65.0%) patients and left atrial thrombus was present in 14 (17.5%) patients (Table 2).

Table 2. Characteristics of mitral valve disease

Variable	**Value**
Average of NYHA Class	2.6 ± 0.5
Atrial Fibrillation	52 (65.0%)
Mitral Pathology	
Isolated Severe Mitral Stenosis	29 (36.3%)
Isolated Severe Mitral Regurgitation	13 (16.4%)
Mixed Mitral Stenosis and Regurgitation	38 (47.4%)
Wilkins score	9.6 ± 0.9 (min:8; max:12)
Left ventrical Ejection Fraction (%)	64.5 ± 7.3 (min:39; max:78)
Pulmonary Artery Systolic Pressure (mmHg)	48.4 ± 15.2 (min:25; max:95)
Left Atrial Diameter (mm)	53.2 ± 7.6 (min:36; max:80)
Left Atrial Thrombus	14 (17.5%)
3+ or worse Tricuspid Regurgitation	14 (17.5%)

2. Operation and Outcomes

57(71.2%) patients underwent mechanical mitral valve replacement by continuous suture technique, 23(28.8%) patients were replaced the bioprosthetic valve with the interrupted suture technique. Valve sizes were 27mm in 38 (47.5%), 29mm in 25 (31.3%), 31mm in 13 (16.3%) patients, and 33mm in 4 (4.9%) patients. Left atrial appendage exclusion was performed in 23 (28.8%) patients. 22 (27.5%) were performed concomitant tricuspid valve repair with ring. Intermittent antegrade warm blood cardioplegia was used for myocardial protection in all patients. Mean CPB and aortic cross-clamp times were 93.7 ± 17.9 and 61.9 ± 14.6 minutes, respectively. No patients required conversion to a full sternotomy (Table 3).

Table 3. Operative characteristics

Variable	Value
Cardiopulmonary Bypass Time (minutes)	93.7 ± 17.9 (min:61; max:151)
Aortic Cross Clamp Time (minutes)	61.9 ± 14.6 (min:33; max:107)
Valve type	
Bioprosthetic valve	23(28.8%)
Mechanical valve	57(71.2%)
Technique of valve replacement	
Continuous suture	57(71.2%)
Interrupted suture	23(28.8%)
Concomitant tricuspid repair	22(27.5%)
Left Atrial Appendage Exclusion	23(28.8%)
Conversion to Sternotomy	0 (0%)

All cases were conducted with femoral cannulation for CPB with zero cases of iatrogenic aortic dissection, vascular injury, or distal limb ischemia. All patients were able to be separated from CPB without the need for mechanical circulatory support. Postoperative inotropic support was required temporarily in 7 (30.4%) patient. Mean total mechanical ventilation time was 15.8 ± 24.7 hours (range 3 – 184 hours, median:). Mean intensive care unit (ICU) length of stay (LOS) was 54.5 ± 79.9 hours (range 24 -720 hours; median 39), and mean hospital LOS was 10.5 ± 4.7 days (range 6-30 days).

Postoperative complications included groin seroma in 1 patient (1.3%) and haemothorax or pneumothorax in 7 (8.8%) patients. No patients suffered a cerebrovascular accident. There is only one patients bleeding requiring reoperation. The mean total volume of chest drain output at 1, 3, and 24-hours was 57.3 ± 32.9ml, 147.0 ± 81.5ml, and 355.3 ± 209.8 ml, respectively. Overall 30-day mortality was 1.3%. Pre-discharge echocardiography revealed no residual mitral gradient in all patients with postoperative pulmonary artery systolic pressure were 34.1 ± 8.6mmHg (range 21 - 60 mmHg) and mean of prosthetic valve area were 2.8 ± 0.6 cm^2 (Table 4).

Table 4. Early Postoperative outcomes

Variable	Value
Reoperation for bleeding	1 (1.3%)
Paravalvular leak	0 (0%)

Variable	Value
Area of prosthetic valve	2.8 ± 0.6 (min:1.5; max:3.8)
Pulmonary artery systolic pressure	34.1 ± 8.6 (min:21; max:60)
Groin seroma	1 (1.3%)
Pneumothorax or hemothorax	7 (8.8%)
Postoperative inotropic support	52 (65.0%)
Total ventilation time (hours)	15.8 ± 24.7 (min:3; max:184; median:12)
ICU length of stay (hours)	54.5 ± 79.9 (min:24; max:720; median:39)
Hospital length of stay (days)	10.5 ± 4.7 (min:6; max:30)
Readmission within 30 days	5 (6.3%)
Early (30-day) mortality	1 (1.3%)

IV. DISCUSSION

Traditional median sternotomy allows good exposure for mitral valve replacement. This approach has been shown to have reliable efficacy and safety with excellent short-term as well as long-term results. However, the cons of this approach is the large incisions and trauma, and complications associated sternum. The minimally invasive mitral valve surgery has been implemented since the early 1990s via the para-sternal, partial or mini-thoracotomy incision. Since the first successful case of video-assisted minimally invasive mitral valve repair performed by Carpentier et al. in 1996, this approach has become more commonly throughout the world [4]. In Vietnam, this technique has been applied and implemented in some large centers since 2003 and has obtained favorable initial results.

However, there is a difference in the characteristics of mitral valve pathology between Vietnam as well as developing countries in Asia, Africa, and Western countries [1]. In developed countries, the principal cause of mitral valve disease is mainly degeneration, ischemic cardiomyopathy or mitral annular calcification which is suitable for the indication of mitral valve repair. Many studies of minimally invasive mitral valve surgery for treatment of these pathologies have been reported. The results demonstrated the rate of mitral valve repair, mortality, morbidity, the short-term and long-term outcomes of minimally invasive mitral valve surgery were comparable to conventional sternotomy [5],[6],[7],[9]. By contrast, the mitral valve pathology in Vietnam remains predominantly rheumatic valve disease. Mitral valve is the most often damaged in rheumatic heart disease resulting in stenosis, regurgitation or mixed injury [10]. In our study, the proportion of stenosis, regurgitation and mixed injury accounted for 36.3%, 16.3% and 47.4%, respectively. With the advancement of interventional cardiology, isolated mitral valve stenosis is often treated by percutaneous dilatation, except cases of severe damage not suitable for dilatation. Most of the cases of rheumatic mitral valve disease with severe lesions are required mitral valve replacement. Some authors advocate repairing rheumatic valve lesions at an early stage,

however, rheumatic valve repair surgery is often complicated, combining multiple techniques. Although the fundamental results are promising, long-term follow-up will be needed for validation of outcomes [11].

Another feature of rheumatic valve disease is more common in young patients. Mitral valve stenosis usually appears before the age of 20, but the disease is chronically progressing, in early-stage may not manifest symptoms. When the mitral valve progresses severe stenosis, the left atrial pressure increases, leading to hypertensive pressure pulmonary artery, the patients manifest symptoms of exertional dyspnea and/or decreased exercise tolerance [8]. Patients often need mitral valve surgery in the fifty to sixty of ages. In addition, due to low educational level and financial factors, patients often come to the hospital late with severe valve lesions accompanied by atrial fibrillation. In our study the average age of patients is 49.9 ± 9.5 years. With the characteristics of severe valve lesions accompanied by atrial fibrillation, the most of patients with mitral valve have indication mechanical valve replacement, except some individual cases such as young female, contraindication to anticoagulation with a vitamin K antagonist. In our cohort, the rate of mechanical mitral valve replacement account for 71.2%.

Recent meta-analyses and reviews including numerous studies and patients have outlined the advantages and disadvantages of mini-MVS. A systematic review of Lucà et al. demonstrated that mini-MVS may be associated with decreased bleeding, blood product transfusion, atrial fibrillation, sternal wound infection, scar dissatisfaction, intensive care unit and hospital length of stay, with more rapid return to normal activity. However, mini-MVS was also associated with increased cross-clamp, CPB, and overall procedural times, as well as risk of stroke, and iatrogenic aortic dissection [6]. A larger and more recent meta-analysis by Sündermann et al. including 45 studies and more than 20,000 patients compared mitral valve surgery through right lateral mini-thoracotomy and conventional sternotomy. This report again demonstrated similar mortality and major complications with both techniques, but significantly shorter intensive care unit and hospital stay as well as lower blood transfusions among the mini-MVS group. Importantly, the risk of death and stroke were each very low at individual high-volume centers with experienced teams. However, increased cross-clamp, cardiopulmonary bypass, and procedural times were again seen among most mini-MVS studies included for analysis [9].

The invention of the CPB has played a crucial role in the history of heart surgery, facilitating progressively more difficult operations with declining complication rates when operating on the arrested heart. Advantages aside, adverse effects of prolonged CPB are also well-established. Acute phase reactants including protease cascades, leucocyte, and platelet activation after exposure of blood to the CPB circuit cause systemic inflammation and subsequent tissue injury. Iterative improvement in CPB technology have served to mitigate, but not eliminate these factors, as well as the risk of stroke with prolonged CPB requirements [12]. Cardioplegic arrest duration is also known to effect postoperative cardiac function. Hellgreen et al. found that CPB time greater than 180 minutes and aortic cross clamp time greater than 150 minutes independently increased the risk for early mortality [13]. On this basis, prolonged CPB and cross-clamp times have remained the major drawback of mini-

MVS. Therefore, in addition to improvements in CPB circuit technology, it remains important to improve surgical techniques to reduce CPB and cross-clamp times further. For that reason, we applied the technique continuous suture for mechanical valve replacement in order to reduce the cross-clamp time as well as the CPB time in our research.

Continuous suture techniques in mitral valve replacement were originally introduced with the goal of reducing CPB time and cross-clamp times. Cooley et al. suggested using a simple, continuous suture for valvular implantation takes less time and may be more secure than when individual sutures are used. In addition, the need for felt pledgets, which may theoretically harbor bacteria, is eliminated [14].

Additionally, knot tying in minimally invasive cardiac surgery may be more difficult and time consuming, as surgeons have to perform such tasks in deep spaces and smaller operative fields. Dedicated techniques and technology have been introduced recently to simplify and expedite this task. Nitinol U-clips popularized by surgeons at East Carolina University and the Cor-Knot device (LSI Solutions Inc., Victor, NY, USA) have both been utilized for faster knot tying to reduce operating times in robotically assisted mitral valve repair [15]. We contend that the continuous suture technique offers expediency by minimizing the repetitive nature of conventional knot tying compared to an interrupted suture technique.

In our initial cohort, mean aortic cross-clamp (61.9 minutes) and CPB (93.7 minutes) times were markedly shorter than mean times presented in a recent meta-analysis by Cheng and colleagues, of 95 and 144 minutes respectively [3]. We recognize, however, that the continuous suture technique represents one of several approaches to help reduced operative times. Successful implementation requires a learning curve, use of dedicated long-shafted instruments, and other elements unique to mini-MVS. This technique has also some drawbacks. Surgeons should consider familiarity with this technique via conventional mitral valve replacement before application in a minimally invasive setting. Occasionally, significant mitral annular calcification requiring debridement may leave the mitral annulus too fragile to use a continuous suture technique alone, and in such cases, we utilize interrupted or semi-continuous suturing as part of annular reconstruction. In our experience, most patients with rheumatic mitral valve disease have a thick and secure mitral annulus, which is suitable for performing this continuous suture technique safely.

In our early experience, 52 patient required temporary postoperative inotrope support, and both mean total ventilation time and ICU LOS were reasonably short. Moreover, no severe postoperative complications have occurred to date. Overall 30-day mortality was 1,3% and pre-discharge echocardiography has consistently revealed no residual gradient.

V. CONCLUSIONS

We report preliminary results for minimally invasive mitral valve replacement in patients suffering rheumatic mitral pathology. Our results demonstrate that the minimally invasive mitral valve replacement can be performed safely and effectively. Using the technique continuous suture help reduce cross-clamp and CPB times. Long-term follow-up and additional cases will be needed for validation of our experience and more detailed examination of results.

ACKNOWLEDGEMENTS: None

REFERENCES

1. Seckeler M.D., Hoke T.R. (2011). The worldwide epidemiology of acute rheumatic fever and rheumatic heart disease. *Clin Epidemiol*. 3, 67-84.
2. Yau T.M., et al. (2000). Mitral valve repair and replacement for rheumatic disease. *J Thorac Cardiovasc Surg*. 119 (1), 53-60.
3. Cheng D.C., et al. (2011). Minimally invasive versus conventional open mitral valve surgery: a meta-analysis and systematic review. *Innovations (Phila)*. 6 (2), 84-103.
4. Carpentier A., et al. (1996). [Open heart operation under videosurgery and minithoracotomy. First case (mitral valvuloplasty) operated with success]. *C R Acad Sci III*. 319 (3), 219-23.
5. Ritwick B., et al. (2013). Minimally invasive mitral valve procedures: the current state. *Minim Invasive Surg*. 2013, 679276.
6. Luca F., et al. (2013). Minimally invasive mitral valve surgery: a systematic review. *Minim Invasive Surg*. 2013, 179569.
7. Modi P., Hassan A., Chitwood W.R., Jr. (2008). Minimally invasive mitral valve surgery: a systematic review and meta-analysis. *Eur J Cardiothorac Surg*. 34 (5), 943-52.
8. Nishimura R.A., et al. (2014). 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Thorac Cardiovasc Surg*. 148 (1), e1-e132.
9. Sundermann S.H., et al. (2014). Mitral valve surgery: right lateral minithoracotomy or sternotomy? A systematic review and meta-analysis. *J Thorac Cardiovasc Surg*. 148 (5), 1989-1995 e4.
10. Selzer A., Cohn K.E. (1972). Natural history of mitral stenosis: a review. *Circulation*. 45 (4), 878-90.
11. Fu J.T., et al. (2017). A meta-analysis of late outcomes of mitral valve repair in patients with rheumatic heart disease. *J Thorac Dis*. 9 (11), 4366-4375.
12. Murphy G.J., Angelini G.D. (2004). Side effects of cardiopulmonary bypass: what is the reality? *J Card Surg*. 19 (6), 481-8.
13. Hellgren L., Kvidal P., Stahle E. (2002). Improved early results after heart valve surgery over the last decade. *Eur J Cardiothorac Surg*. 22 (6), 904-11.
14. Cooley D.A. (1992). Simplified techniques of valve replacement. *J Card Surg*. 7 (4), 357-62.
15. Nifong LW, et al. *Significant Reduction in Operative Times Using Cor-Knot™ In Robot-Assisted Mitral Valve Repair*. in *International Society for Minimally Invasive Cardiothoracic Surgery*. 2013.

Dual ICD therapy on a long QT syndrome patient along with pseudo block A-V 2:1

Phong Dinh Phan [1,2]✉, Linh Duy Nguyen [1], Kien Vo Le [1]
Viet Tuan Tran [1,2], Viet Tuan Nguyen [2], Phong Viet Dang [1]
[1] Vietnam National Heart Institute, Bach Mai Hospital
[2] Hanoi Medical University

SUMMARY

A 10-year-old girl was admitted to the hospital after experiencing multiple episodes of loss of consciousness due to ventricular tachycardia on the background of congenital long QT syndrome. The patient's ECG reveals two distinct and unusual features: T wave alternation and 2:1 atrio-ventricular block. After admission, she continued to appear unconscious with monitoring images of ventricular tachycardia and torsades de pointes. The patient was resuscitated and a temporary pacemaker was implanted. Finally, the patient was appointed to implant a dual ICD device. However, when analyzing the device's tracking, it was found that:

Her native rhythm was sinus rhythm with a long QT of 680 ms when the sinus rhythm cycle longer than 1400 ms, its can lead to atrial-ventricular conduction of 2:1. Finally, the VVI anti-bradycardia mode was set to decrease ventricular pacing, which causes biventricular synchronization primitives, as well as the phenomenon of ventricular pacing on the T wave, which causes polymorphic VT. This leads to optimal ICD in minimizing ATP and electrical shock.

BACKGROUND

Long QT syndrome (LQTS) is a congenital disorder characterized by prolongation of QT interval in the electrocardiogram (ECG) and a propensity to develop ventricular arrhythmias, which may lead to syncope, cardiac arrest or sudden death. The extreme prolongation of ventricular action potential duration that occurs in some of the long QT syndromes may result in two forms of alternating activity of the heart included of T wave alternation and a "pseudo" 2:1 atrio-ventricular block, both of which are rate dependent. T-wave alternans (TWA), a phenomenon of beat-to-beat variability in the repolarization phase of the ventricles, has been closely associated with an increased risk of ventricular tachyarrhythmic events (VTE) and sudden cardiac death (SCD). Futhermore, a "pseudo" 2:1 atrio-ventricalar (AV) block can hide a condition of asymptomatic sinus node dysfunction (sick sinus syndrome) or high degree AV block. Electrophysiology studies is essential before deciding to implant an ICD, which is extremely important for optimal patient outcomes, epesically patient have AV block in their surface cardiogram.

Keywords: Long QT syndrome, sudden cardiac death, T-wave alternans, a "pseudo" 2:1 atrio-ventricular (AV) block, ICD.

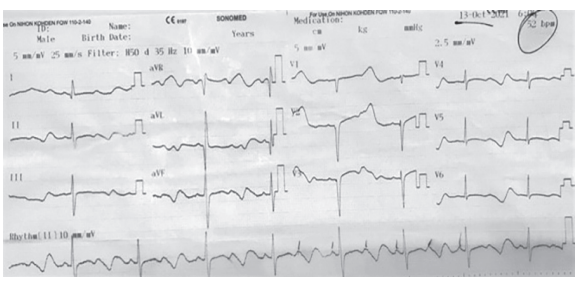
CASE REPRESENTATION

A 10-year-old girl had been transported

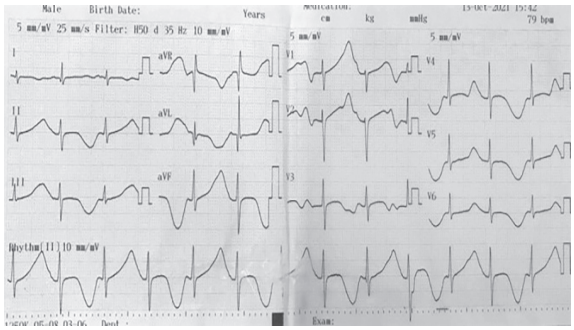
Correspondence to: Dr. Phong Dinh Phan. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam; Hanoi Medical University, Hanoi, Vietnam. Email: phongvtm.@gmail.com

to the emergency room after suffering head trauma. She has a history of 3-4 occurrences of loss of consciousness in the previous 2 days, each lasting one minute. She had a headache and feels dizzy before each incident. She had no seizures or agina throughout each incident. She awoke after this event. **Medical history:** a diagnosis of bradycardia six years previously. She had no history of drug ingestion in recent time. **Family history:** There were no episodes of unexplained sudden death in her family. Her vital signs at time of administration were in normal range: (1) A temperature of 36.8 degrees Celsius, (2) A heart rate of 52 cycles per minute, (3) A respiratory rate of 20 breaths per minute with her oxygen saturation of 98% (at rest in room air), and (4) Blood pressure of 120/80 mmHg. Her examination had revealed no positive findings. She had a further episode of loss of consciousness after 30 minutes of hospitalization. Her monitoring had showed she has complete AV block, torsades de pointes, and non-sustained VT. The patient was resuscitated and a temporary pacemaker was implanted. Finally, the patient was appointed to implant a dual ICD.

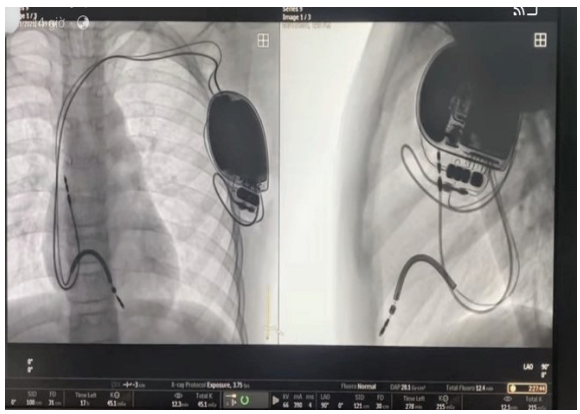
INVESTIGATIONS



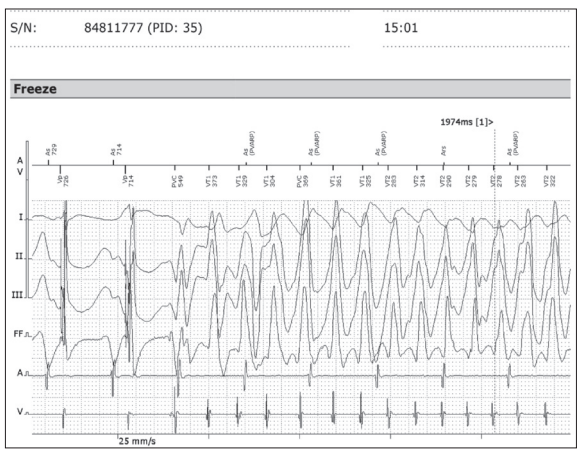
Picture 01. ECG when the patient is admitted to the hospital: Sinus rhythm, QTc = 720 ms and conduction of 2 atria followed by 1 ventricle activation.



Picture 02. ECG 5 hours after admission: Sinus rhythm, QTc = 680 ms and T wave alternation.



Picture 03. X-ray image of a dual ICD after implantation



Picture 04. Ventricular pacing induced VT shortly after connection to the atrial and ventricular electrodes of ICD.

S/N:	84811777 (PID: 35)	15:35
Parameters - Bradycardia		
Mode		VVI
Basic rate		
Basic rate [bpm]		40
Rate hysteresis [bpm]		OFF
Scan/Repetitive		
Night rate [bpm]		OFF
Night begins		
Night ends		

Picture 05. VVI - The last ICD setting pacing mode is selected to suit the patient

Other investgations:

TTE: LVEF = 35% and LV diameter (Dd) = 55 mm.

MSCT cerebral vascular: No sign of occlusion, no cerebrovascular malformation.

Her blood sugar level, serum sodium, potassium, calcium, and magnesium were in a normal range.

DIAGNOSIS

Based on the symptoms and ECG findings a diagnosis of LQTS and high-grade AV block was made.

TREATMENT

Her ESP in previous 6 years show that she had non-persistent AV block with HV interval of 74 ms. She had been indicated to temporary cardiac pacing. Because Beta-blocker therapy was contraindicated, so she had been scheduled for a dual implantable cardioverter defibrillator (ICD).

DISSCUSION

Congenital long QT syndrome (LQTS) is characterized by heart rate corrected QT interval prolongation and potentially fatal arrhythmias, resulting in syncope and sudden death. (1) QTc in this patient was determined as 680 ms using the Bazett formula for measuring QT duration. It meets the criteria for long-QT syndrome (QTc > 460 ms in women). According to Schwartz criteria, (2) this patient has: QT duration (as determined by the Bazett's formula) = 680 ms >= 480 ms (1 point) this patient also had confirmed that no drug consumption. She had a normal blood test with K, Mg in serum. Torsades de Ponites (2 points) Low resting heart rate (1 points) and Syncope (0.5 points). This patient's total score = 4.5 points > 3.5, where this score suggests a strong probability of LQTS. According to the Hobbs et al, (3) in LQTS, the timing and frequency of syncope, QTc prolongation, and sex were predictive of risk for aborted cardiac arrest and sudden cardiac death during adolescence. Additional approaches for more accurately assessing LQTS on the ECG have been developed in recent years, including the use of artificial intelligence in establishing the diagnosis. (4)

T-wave alternans is an uncommonly observed electrocardiographic (ECG) finding of beat-to-beat alternation in T-wave shape or amplitude. "Macroscopic" T-wave alternans, visible to the naked eye, is associated with a prolonged QT interval and long QT syndrome (LQTS). T-wave alternans may portend a rapidly developing and life-threatening scenario, and its recognition is crucial to prevent progression to lethal

arrhythmias. (5) TWA can be found in a variety of diseases, including congestive heart failure, acute ischemia, medication side effects, Brugada syndrome, and hypertrophic cardiomyopathy. Though the mechanism of TWA may vary in these different disorders, there are typically two basic hypotheses to describe the causes of TWA: the action potetial duration restitution and the calcium-cycling (Calcium Restitution). Long-QT syndrome is distinct in that T-wave alternans and arrhythmias are triggered at low rather than high heart rates. The involvement of calcium handling as the major mechanism of TWA is similarly unknown, while it is thought to have a role. (6), (7) This patient was one of a few cases of macroscopic TWA in LQTS documented in Vietnam. T-wave alternans were difficult to detect in her administration's ECG (Picture 01). However, the second ECG (Picture 02) after 5 hours of hospitalization showed negative T-waves alternating with positive T-waves. The occurrence of T-wave alternans in electrocardiographic signals was recently linked to susceptibility to ventricular arrhythmias and sudden cardiac death. (8)

According to the main treatment principle: Beta blockers are the mainstay of therapy for the prevention of cardiac events and implantable defibrillators for secondary prevention. (9) The patient in this case with an indication for atrial pacing included a history of symptomatic sinus high degree AV block, sinus arrest with syncope and a history of Torsades de Ponites. Dual-chamber ICDs are indicated for this patient. Dual-chamber ICD was considered to be an effective therapy for this condition. When the device's tracking was examined, it was discovered that her native rhythm was sinus rhythm with a long QT of 680 ms. When the sinus rhythm cycle is longer than 1400 ms, it can lead to atrial-ventricular conduction of 2:1. Finally, the VVI anti-bradycardia mode was adjusted to reduce ventricular pacing, which creates biventricular synchronization primitives, as well as ventricular pacing on the T wave, which generates polymorphic VT. This results in ideal ICD in terms of ATP and electrical shock.

LEARNING POINTS

1. In summary, congenital LQTS is an inheritable entity characterised by a prolonged heart-rate corrected QT interval, and it associates with malignant arrhythmias at young age.

2. The extreme prolongation of ventricular action potential duration that occurs in some of the long QT syndromes may result in two forms of alternating activity of the heart: a T wave alternation and a "pseudo" 2:1 atrio-ventricular (AV) block.

3. Electrophysiology studies are required before determining to implant an ICD, which is critical for optimal clinical outcomes if indeed the patient demonstrates AV block on their surface electrocardiogram.

DECLARATION OF PATIENT CONSENT

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given her consent for her images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Schwartz PJ. 1970–2020: 50 years of research on the long QT syndrome—from almost zero knowledge to precision medicine. Eur Heart J. 2021 Mar 14;42(11):1063–72.
2. Schwartz PJ, Ackerman MJ. The long QT syndrome: a transatlantic clinical approach to diagnosis and therapy. Eur Heart J. 2013 Oct 2;34(40):3109–16.
3. Hobbs JB, Peterson DR, Moss AJ, McNitt S, Zareba W, Goldenberg I, et al. Risk of Aborted Cardiac Arrest or Sudden Cardiac Death During Adolescence in the Long-QT Syndrome. JAMA. 2006 Sep 13;296(10):1249.
4. Bos JM, Attia ZI, Albert DE, Noseworthy PA, Friedman PA, Ackerman MJ. Use of Artificial Intelligence and Deep Neural Networks in Evaluation of Patients with Electrocardiographically Concealed Long QT Syndrome from the Surface 12-Lead Electrocardiogram. JAMA Cardiol. 2021 May 1;6(5):532.
5. Zareba W, Moss AJ, le Cessie S, Hall WJ. T wave alternans in idiopathic long QT syndrome. J Am Coll Cardiol. 1994 Jun;23(7):1541–6.
6. Shimizu W, Antzelevitch C. Cellular and Ionic Basis for T-Wave Alternans Under Long-QT Conditions. Circulation. 1999 Mar 23;99(11):1499–507.
7. Jayakrishnan MP, Krishnakumar P. Macroscopic T wave alternans in long QT syndrome. Indian J Pediatr. 2006 Jun;73(6):539–40.
8. Pastore JM, Girouard SD, Laurita KR, Akar FG, Rosenbaum DS. Mechanism Linking T-Wave Alternans to the Genesis of Cardiac Fibrillation. Circulation. 1999 Mar 16;99(10):1385–94.
9. Abu-Zeitone A, Peterson DR, Polonsky B, McNitt S, Moss AJ. Efficacy of Different Beta-Blockers in the Treatment of Long QT Syndrome. J Am Coll Cardiol. 2014 Sep;64(13):1352–8.

Rare perforated giant aneurysm of the posterior mitral valve leaflet-a case report

Yen Thi Hai Nguyen✉, Tuan Van Le, Hoai Thi Thu Nguyen

Vietnam National Heart Institute, Bach Mai Hospital

ABSTRACT

Introduction: Although perforation leaflet of Mitral valve aneurysms (MVAs) are rare, they usually occur commonly in the anterior leaflet mitral valve is associated with endocarditis of the aortic valve. Various mechanisms have been suggested for the etiopathogenesis of MVA.

Case presentation: We present a case with perforated on the huge posterior leaflet mitral valve aneurysm due to infective endocarditis (IE) without significant regurgitation aortic valve, initially mistaken diagnosis of myxoma atria tumor, which was confirmed at transesophageal cardiogram.

Conclusion: Perforated giant aneurysm of the posterior mitral leaflet valve is a rare but deadly complication of IE. It is mistaken to diagnose with TEE in the mitral valve aneurysm with vegetation and emphasize the role of TEE in early accurate diagnosis.

Key words: Infectious endocarditis; mitral valve leaflet aneurysm; TEE; posterior mitral valve; Staphylococcus group endocarditis.

INTRODUCTION

In 1729, Morand describes the first case of mitral valve aneurysm [1]. Mitral valve aneurysm (MVA) is very scarce, reported cases are rare and often the consequence of infective endocarditis. A mitral valve aneurysm is defined as a localized, thin-walled saccular bulge of the mitral leaflet toward the left atrium, and communication between the aneurysm and the left ventricle during the cardiac cycle, with systolic expansion and diastolic collapse. The color flow Doppler image of a perforation was described as a high-velocity turbulent jet traversing a valve leaflet in systole.

Perforation or rupture is the most deadly complication of mitral valve aneurysm, as it results in rapid hemodynamic deterioration leading to acute pulmonary edema from acute severe mitral regurgitation [2]. So that the awareness of this rare entity will lead to timely diagnosis and treatment, which can help prevent this catastrophic complication.

We report a case that was supper from comorbidities and a perforated giant aneurysm of the posterior mitral valve leaflet to contributes to the obvious comprehensiveness of these circumstances. On the other hand, making a point of role of TEE in early exact diagnosis this statement. Our case report was prepared following the CARE Guidelines and can be useful for both education and clinical practice purposes.

CASE REPORT

+ ***Information of the patient:*** Woman, 81 year-old

+ ***Symptoms and history:***

• Present a case of a 81-year-old hypertension, diabetic woman who was hospitalized due to bilateral cellulitis of the lower limbs and sudden weakness on right side of the body, accompanying confusion.

Correspondence to: Dr. Yen Thi Hai Nguyen. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam. Email: dr.nguyenthihaiyen.cardio@gmail.com

• Her family told that she had complained of the claudication several months before admitted hospital. With a history of ulcer and swelling bilateral three toes, particularly right and left big toe without medical care for several months, she presented with symptoms of worsening shortness of breath, subjective high-grade fever, orthopnoea, paroxysmal nocturnal dyspnea, and chest pain for a week.

+ *Clinical findings:*

She had suffered from paralyzed right side in recent day admit our hospital. Vital signs were blood pressure of 130/80 mmHg, pulse rate of 100 beats/min, respiration rate of 23 breaths/min, oxygen saturation of 93%, and body temperature of 390C. On the physical examination, there were peripheral skin lesions in right and left toe. Especially, the big toe presented ulcered, yellowish pus. Cardiac auscultation revealed a grade 3/6 systolic heart murmur, findings were bilateral rales in lung bases and electrocardiography demonstrated atrial fibrillation.

+ *Laboratory tests*

• The blood chemistries, including coagulation studies, C-reactive protein, the complete blood count shows table 1, in which both leukocytosis and C-reactive protein (CRP) are sharply increased.

• A chest radiograph showed increased interstitial markings on both lower lung fields.

• Limb vessel ultrasound shows severe stenosis right anterior tibia artery, chronic total occlusion right posterior and left anterior tibia artery, seriously stenosis left superficial femoral artery.

• CT scanner reveals multiple and bilateral infarcts.

• A routine transthoracic echocardiogram was carried out on the first hospital day in the bed. The left ventricle was not dilated, had preserved systolic function, and suspected a huge myxoma left atria. Consequently, our colleges transfer this patient to us to check transesophageal echocardiogram (TEE). We performed TEE in the bed to defined either myxoma atrial tumor or vegetational mitral valve. A markedly pulsating aneurysm on the posterior mitral valve leaflet was detected, with the cavity expanding in early systole (1.6-2.5 cm) and collapsing in diastole (Fig.1 and fig.2). Furthermore, a perforation of the lesion into the left atrium was demonstrated (Fig.3). An eccentric jet of moderate mitral valve regurgitation was also detected. TEE (video 1) showed mild aortic regurgitation, multiple tiny vegetations on the aortic valve. Tricuspid valve regurgitation was realized moderate degree and pulmonary artery systolic pressure was estimated at 52 mmHg. The pulmonary valve was unremarkable.

• She was performed 3 samples of blood culture. After 4 days her results blood cultures were positive for methicillin-sensitive Staphylococcus aureus.

+ *Timelines:*

9 days on hospital

+ *Diagnostic assessment:*

She was diagnosed with infective endocarditis complicated with mitral valve aneurysm and perforation with comorbidities such as diabetes, hypertension, kidney failure, peripheral artery disease (PAD), and acute ischaemic stroke.

+ *Therapeutic methods:*

She was started on antibiotics on admission hospital day and was performed 3 samples of blood culture. She was supported respiratory by mechanical ventilation.

Her relative denied carrying out aggressive treatment such as surgery, etc...

+ *Outcome:*

Although she did receive intravenous (IV) antibiotic treatment for Staphylococcus aureus (Included Vancomycin combined meropenem), her situation was not better after 9 days and her family decided to stop treatment. She was discharged from our hospital to a care home. We predicted that she can not recover her condition.

DISCUSSIONS

Infective endocarditis is a potentially life-threatening disease if not treated timely. In the peripheral infective skin scenarios, Staphylococcus aureus bloodstream infections have become the primary pathogen of endocarditis. Our patient was not aware and treated early so that she was getting worse conditions such as stroke, pulmonary edema, caused by vegetations, and perforation mitral valve. Several recent reports show that untreated MVA can lead to severe mitral regurgitation and acute pulmonary edema through multiple mechanisms, including perforation of the aneurysm and rupture of the chordae tendineae. It is easy to recognize the perforation of PML with regurgitation jet and mobile larger mass adhere mitral valve in video of our patient. The mainstay of treatment for IE is antibiotics. Surgery is indicated for IE manifested with uncontrolled infection, paravalvular abscess involving the aortic root, resistant microorganisms, and the presence of large vegetations with a high risk of embolization [3]. Our patient has been treated without valve replacement surgery because of her family refusal and comorbidities.

Mitral valve aneurysm is a rare entity with the incidence reported as only 0.2-0.29% [2,4]. The anterior leaflet is more commonly involved than the posterior leaflet valve [4,5]. Besides, the MVA is a rare complication of infective endocarditis, and it usually involves an anterior mitral leaflet and is associated with aortic regurgitation (jet lesion). Posterior mitral leaflet aneurysms and often complicated by leaflet perforation are extremely rare with very few reported cases [6,7]. To our best knowledge, a paucity of mitral valve aneurysm has been reported by systematic literature search (via PubMed, Embase, Scopus, and Google Scholar). The perforation of the posterior leaflet mitral valve aneurysm is rare, and only two studies that have remarkable case reports are available in the literature. The first, one study was performed by José Luiz B. Pena et al released in 2017, reported 18 patients during a 17-year. The aneurysm was located on the anterior leaflet in 16 cases, and on the posterior leaflet in two cases [5]. Another study with 12 cases, retrospectively, on TEE, aneurysms were located in the posterior mitral leaflet only one patient [4]. The remains of other reports are sparsely cases.

Furthermore, mitral valve aneurysms are commonly associate with aortic valve IE, several mechanisms have also been suggested, which include aortic regurgitant jet, contact between vegetations of the aortic valve and the anterior mitral leaflet and spread of the infectious process to the adjacent mitral valve tissue[8-10]. In the setting of aortic valve endocarditis, the etiology of development of the MVA is the physical trauma and occult infection incurred by infected aortic regurgitant jet to anterior mitral leaflet[11]. In the absence of endocarditis, stress alone due to a regurgitant aortic jet has been speculated to be the most possible cause of mitral aneurysm[4]. Our case seems to be a very rare incident since the perforation of the aneurysm was detected on the posterior mitral valve leaflet, where mechanical stress due to aortic regurgitation was less affected compared to that acting on the anterior one. Additionally, our patient the aortic valve was only mildly regurgitation. The mechanism associated with aneurysm development in the posterior leaflet may be weakening of the leaflet caused by infections or other pathologies[12-14]

Diagnosis of a perforation of the posterior mitral leaflet can be made by TTE or transesophageal echocardiogram, but a transesophageal echocardiogram is more sensitive and accurate [15]. On TTE, it is mistaken for myxoma tumor and is limited in obese, lung disease, or mechanical ventilation situations. This patient was misinterpreted in TTE because of

several reasons. Firstly, mechanical ventilation, old-women, thick chest lead to difficulty to acquire clear images from TEE. In addition, huge mobile mass outpouching mitral valve can make erroneous of sonographer [16]. Moreover, this patient had presented concomitantly acute stroke and extremely infection that can happen in both infective endocarditis and myxoma tumor. So that, we had done TEE immediately to realize precisely diagnosis.

In brief, our patient had exposure to many conditions such as diabetes, ulcer, and swelling toes that leads to facileness of endocarditis. Consequently, perforation of mitral valve and stroke were required concomitantly as complications of IE. However, perforation of posterior mitral leaflet aneurysm is rarely a complication of this situation. So far we have not acquired full data to elucidate the etiology of MVA. We hope this case contributes to the clear comprehensiveness of these circumstances.

PATIENT PERSPECTIVE

Because Our patient was unconscious, we asked her family to agree and sign consent form. Relative's patient agrees with us to share her information to education and clinical practice purposes.

CONCLUSIONS:

Perforated giant aneurysm of the posterior mitral leaflet valve is a rare but deadly complication of IE that can lead to severe morbidity and mortality when is not promptly aware and not suitably managed. It is mistaken to diagnose with TTE in the mitral valve aneurysm with vegetation and emphasize the role of TEE in early accurate diagnosis.

ABBREVIATIONS

CRP: C-reactive protein, Nt-ProBNP: N-terminal (NT)-prohormone B-type natriuretic peptide, pCO2: partial pressure of carbon dioxide, pO2: partial pressure of oxygen; MVA: Mitral valve aneurysm; PML: Posterior of mitral leaflet; TTE: Transthoracic cardiogram; TEE: Transesophasgeal cardiogram; IE: infective endocarditis; PAD: peripheral artery disease.

HUMAN ETHICS

Consent was obtained by all participants in this study.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

First author was involved in the performance TEE examinnation, management of the patient and contributed to writing the manuscript. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

This report involved no sources of funding for any of the authors.

TABLE 1. Selection of Laboratory results at first presentation, at the second presentation and the third presentation, CRP: C-reactive protein, Nt-ProBNP: N-terminal (NT)-prohormone B-type natriuretic peptide, pCO2: partial pressure of carbon dioxide, pO2: partial pressure of oxygen

	1st	2nd	3rd
pH (7.35-7.45)	7.41	7.356	7.43
pCO2 (36-44 mmHg)	30.1	32.7	33.3
pO2 (70-100 mmHg)	61.2	98.1	100.6
Bicarbonate (22,0-29,5 mmol/L)	19.1	17.9	21.7
Base Excess (± 2 mmol/L)	-4.6	-6.7	-2
O2 saturation (95.0-98.0 %)	91.3	97.0	97.9

	1st	2nd	3rd
Lactate (0.5-1.7 mmol/L)	2.77	2.25	n/aa
Leucocytes,x10^9/l	20.88	19.9	29.9
Neutrophil, %	84.5	86.8	84.3
RBC, T/l	3.64	3.39	3.64
Hemoglobin, g/L	96	90	95
Thrombocytes,x10^9/l	328	341	330
Nt-ProBNP, pmol/L	2123.0	n/a	n/a
CRP, mg/dL	31.023	18.547	n/a
Ure, mmol/LL	15.8	26.6	21.8
Creatinine, µmolmol/L	146	212	130

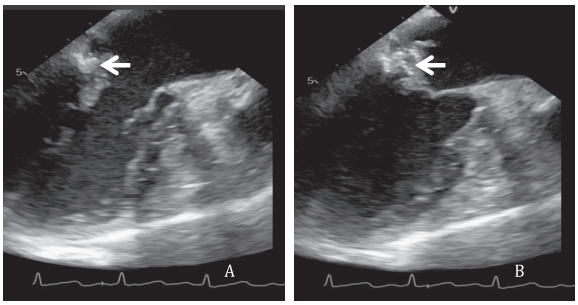


Fig.1. A aneurysm of the mitral valve in left atrium attached to the posterior mitral valve leaflet, collapsing in diastole (A) and expanding in early systole (B) in the middle two chamber view of TEE

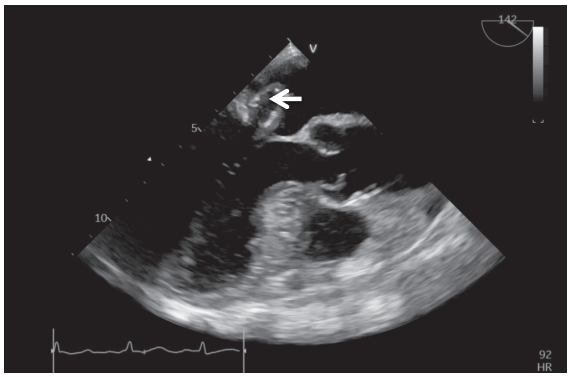


Fig 2. A fluttering perforated aneurysm on the Posterior mitral valve leaflet (1.6.2.5 cm, white arrow) in the long parasternal view of transesophageal echocardiogram

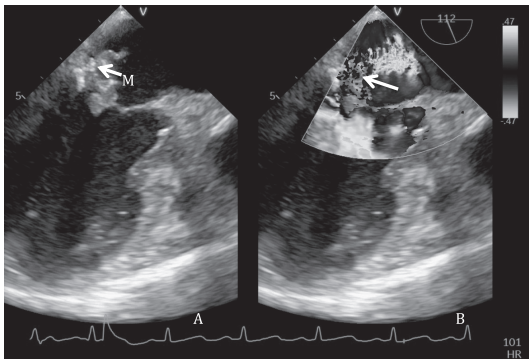
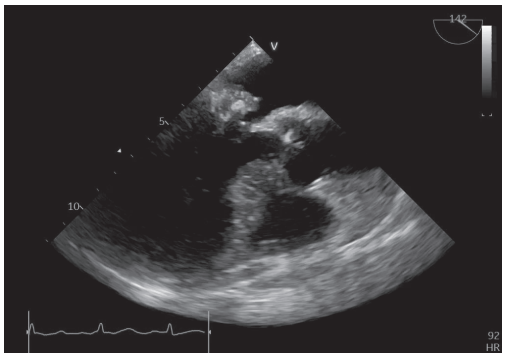


Fig. 3. (A) The mitral valve aneurysm (M) was perforated (red arrows), and regurgitant jets during systole (white arrows) were detected (B).



Video 1. shows mild aortic valve regurgitation and mitral valve aneurysm in the long parasternal view of the transesophageal echocardiogram. (https://youtu.be/KWwuZ6GnROU)

REFERENCES

1. De Luca I CL. Echocardiographic diagnosis of mitral valve aneurysm. *Eur J Cardiol*. 1980;11:325–330. doi:http://dx.doi.org/10.1136/heart.84.5.534

2. Isidre Vilacosta JASR, Cristina Sarriá, Elena Iturralde, Catherine Graupner, Elena Batlle, Vicente Peral, Paloma Aragoncillo, Walter Stoermann. Clinical, anatomic, and echocardiographic characteristics of aneurysms of the mitral valve. *The American Journal of Cardiology*. 1999;84(1):110-113. doi:https://doi.org/10.1016/S0002-9149(99) 00206-4

3. Takayama T TM, Sakai H, Tamaki S, Okabayashi T, Kawashima T et al. Perforated mitral valve aneurysm associated with Libman-Sacks endocarditis. *Intern Med*. 2008;47(18):1605–1608.
4. Ahmet Guler CYK, Ozan M.Gursoy, Yeliz Guler, Ozkan Candan, Taylan Akgun, Mustafa Bulut, Selcuk Pala, Akin I. Izgi, Ali M. Esen, Cevat Kirma, Mehmet Ozkan. Clinical and echocardiographic evaluation of mitral valve aneurysms: a retrospective, single center study. *Int J Cardiovasc Imaging*. 2014;30:535-541. doi:10.1007/s10554-014-0365-4
5. Pena JLB, Bomfim TO, Fortes PRL, Simão-Filho C, de Souza Andrade-Filho J. Mitral valve aneurysms: Clinical characteristics, echocardiographic abnormalities, and possible mechanisms of formation. *Echocardiography*. 2017;34(7):986-991. doi:10.1111/echo.13556
6. Hong SN PG, Skolnick A, Kronzon I. Evaluation of a posterior mitral valve leaflet aneurysm by real time threedimensional transesophageal echocardiography. *Echocardiography*. 2009;26:1089–1091.
7. Unger P AM, Hastir D, Dedobbeleer C, Leeman M. Infective endocarditis presenting as an isolated aneurysm of the posterior mitral leaflet. *Can J Cardiol*. 2012;doi:doi:10.1016/j.cjca.2012.09.010
8. English TAH HM, Cleland WP Ruptured tree aneurysm of mitral valve: a complication of aortic valve endocarditis. *Br Heart J*. 1972;34:434–436.
9. JJ S. Review: mitral valve aneurysms in infective endocarditis: mechanisms, clinical recognition, and treatment. *J Heart Valve Dis*. 2009;18:476–480.
10. Nagai T HA, Arakawa J, Konishi T, Hisadome H, Yoshida M, Tabata H, Ito T, Mitsumaru A, Tanaka Y, Uehata A. Mitral valve aneurysm. *Ultraschall Med*. 2013;34:69–70.
11. Marije E. Werner RKR, Remko S. Kuipers. A Perforated Mitral Valve Aneurysm: A Rare but Serious Complication of Aortic Valve Endocarditis Resulting From a Regurgitant Jet Lesion. *Cureus*. 2020; 12(11) doi:DOI: 10.7759/cureus.11644
12. Kim DJ CK, Jun HJ, Kim YJ, Song YJ, Jhi JH et al Perforated mitral valve aneurysm in the posterior leaflet without ınfective endocarditis. *J Cardiovasc Ultrasound*. 2012;20:100–102.
13. Is¸ık T KM, Ayhan E, Tanbog˘a I˙H Incidental diagnosis of an aneurysm of the mitral valve posterior leaflet. *Anadolu Kardiyol Derg*. 2012;12(8):E40–E41.
14. Tewari S MN, Sinha N Ruptured mitral valve aneurysm: an uncommon cause of acute dyspnoea. *Echocardiography*. 2010;27:119–121.
15. Sousa MJ AV, Cabral S, et al. Mitral valve aneurysm: a se- rious complication of aortic valve endocarditis. *Rev Port Cardiol*. 2016;35(621.e1-621.e5.)
16. Stechert MM PJ, Tseng EE, London MJ Echo rounds: aneurysm of the anterior mitral valve. *Anesth Analg*. 2012;114(1):86–88.

Spectral computed tomography in cardiology

Vu Tuan Nguyen [1]✉, Viet Lan Nguyen [2]

[1] Pham Ngoc Thach University of Medicine

[2] Vietnam National Heart Institute, Bach Mai Hospital

ABSTRACT

Cardiac computed tomography (CT) has become a valuable tool in the equipment of the cardiologist. Many technological advances in CT have occurred recently, including dual-energy CT (DECT) or spectral CT. CT is now considered a reliable tool to assess coronary artery stenosis, but it still has two main areas for improvement. Firstly, difficult estimation of the degree of stenosis in the presence of calcified plaque; secondly, CT needs to be improved in correctly identifying plaque components. Spectral CT permits accurate plaque characterization, assessment of myocardial perfusion, acute myocarditis, non-ischemic dilated cardiomyopathy, determining if shadowing inside a stent is an artifact or restenosis, better delineation of aortic stent graft endoleaks, detection of both acute and chronic pulmonary embolisms. Also, lower contrast and radiation doses of 50-60% and even 90% in some studies.

Currently, both transesophageal ultrasound (TEE) and CT evaluations are necessary before AF ablation. The TEE evaluation reveals that the cardiac thrombi and multislice CT anatomic reconstructions of the left atrium and pulmonary veins guide the isolation procedure.

Keywords: Dual-energy CT, Spectral CT.

I. OVERVIEW

Principles of computed tomography

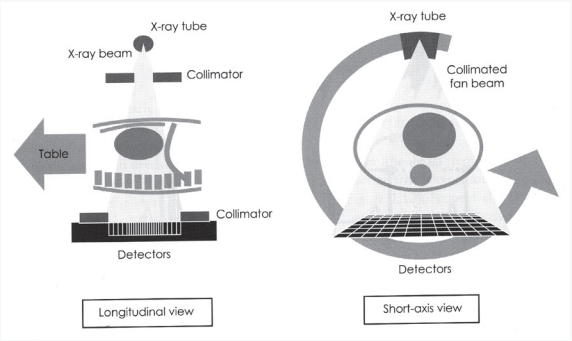


Figure 1.1. Principles of computed tomography. Source: "Pim J de Feyter 2005"(1)

The X-ray tube's beam decreases in intensity as it passes through the body. The unit of measurement for that decrease is the Hounsfiel, abbreviated as HU. Detectors facing the X-ray tube will detect the reduction in intensity, transmit it to the computer's processing system, digitalize the data, and generate a basic cross-sectional image. (Axial source images), the captured structures are re-rendered base on the HU. Data acquisition is usually taken at the end of diastole, e.g., 60% from the preceding R wave. (1)

Correspondence to: Dr. Vu Tuan Nguyen. Pham Ngoc Thach University of Medicine, Ho Chi Minh City, Vietnam. Email: tuanvu2401@gmail.com

Spiral CT was introduced in 1990 with continuously rotating X-ray tubes and a bed moving constantly. This configuration significantly reduced the total scan time but needed to be faster for cardiac scanning. Multi-Slice Computed Tomography (MSCT) or now more commonly known as multi-sensor tomography, also known as Multidetector Computed Tomography MDCT, was introduced in 1998 with four detectors; in 2002, there were 16 detectors; in 2004, 64 detectors, then 128, 256, and 320 respectively, and now 640 detectors (640 - Slice Multidetector Computed tomography). With a 320 or 640 sensor, 0.5mm thin slices can be captured, and a Gantry rotation time as short as 0.33 seconds, thus providing enough temporal and spatial resolution to capture the heart and coronary angiography in just one turn of the X-ray tube (2), (3), (4)

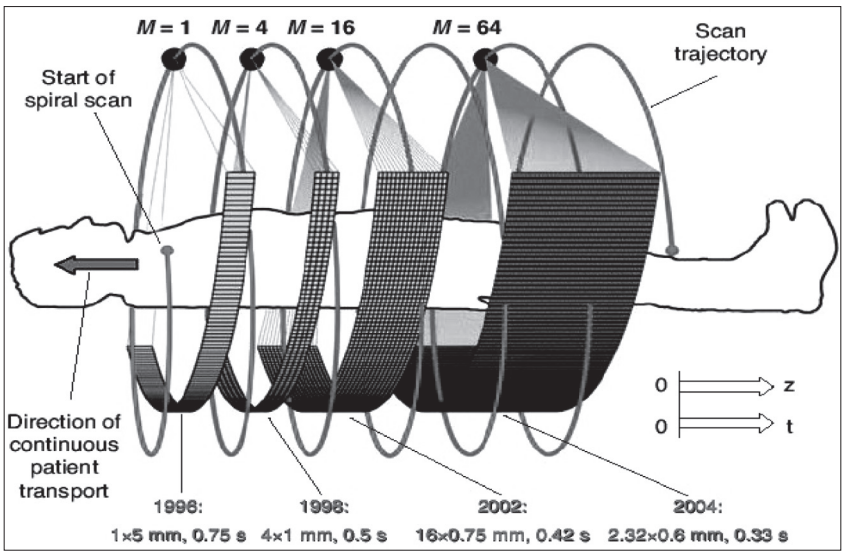


Figure 1.2. Spiral CT và MSCT. (Source: U. Joseph Schoepf 2005) (5)

Spectral Computed Tomography

Spectral CT has received much attention in recent years and is also one of the most interesting topics at the annual meeting of the American Society of Cardiac CT 2019 (Society of Cardiac Computed Tomography 2019). Dual-Energy Computed Tomography represents the latest significant advancement in the field of CT. This technique detects morphology and helps distinguish the chemical composition of examined tissue structures, bringing CT into the functional assessment of organs. This method obtains images that occur at the same or near the same time at low and high energies (kilovolt peaks) (80 kVp and 140kVp). Different energy levels allow the control of two polychromatic spectra to distinguish the densities of two different matters. (6),(7),(8),(9)

The photoelectric effect that produces images depends strongly on the X-ray's photon energy, the nuclear charge Z of the matter, or the binding energy of the electron layer closest to the nuclear, called the K shell. We can distinguish different substances based on the difference in K shell bonding energy at different energies between 80 kVp and 140 kVp. (6),(7),(8),(9)

Principles of Spectral Computed Tomography

Dual-Source Scanner with Dual Detector Arrays:

Siemens Healthcare. (10) Dual-energy CT with one X-ray tube with two energy sources or capable of fast kilovoltage (KV) switching between high and low KV (Single-Source Scanner with Fast Kilovoltage Switching): Canon, GE Healthcare.(10) Single-Source Scanner with Dual Detector Layers: Philips Healthcare.

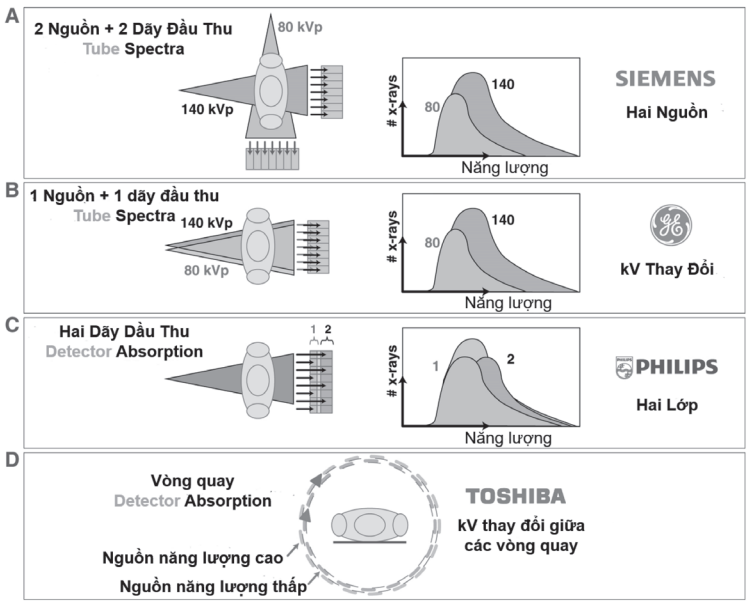


Figure 1.3. Types of spectral computed tomography configuration. (A) Paired detectors with each source operating at a different voltage. Each X-ray source covers a different scanning field. (B) An X-ray source capable of rapidly switching voltages in one revolution. (C) Sensor with two layers made of 2 different materials capable of distinguishing between low energy (upper layer) and high energy (lower layer) photons, with the source operating at a constant voltage. (D) A source-sensor pair with a sequential switching source voltage. (Source: J Am Coll Cardiol Img. 2015 Jun, 8 (6) 710–723)(10)

II. APPLICATIONS OF SPECTRAL COMPUTED TOMOGRAPHY IN CARDIOLOGY

Computed tomography spectrum not only evaluates the degree of coronary artery stenosis but also determines the degree of risk of atherosclerosis, assesses myocardial perfusion, myocarditis, and cardiomyopathy, monitors the function of coronary stents after the intervention, evaluation aortic Graft stents, detecting acute and chronic pulmonary embolism. In addition, the CT spectrum also helps in the differential diagnosis of thrombus or tumors in the heart chambers and investigates mechanical valve movements by reducing artifacts. (10)

1. Evaluating myocardial perfusion

Evaluation of myocardial perfusion is the most valuable application of Spectral Computed Tomography in cardiology. Using contrast may show different pharmacokinetics between normal, ischemic, and infarcted myocardium regions because most tissues, including the myocardium, are mostly water. Reconstruction of water-suppression imaging from dual-energy CT will allow quantification of Iodine and possibly quantification of myocardial perfusion. Myocardial perfusion imaging and Iodine mapping assist in CT spectroscopy as a functional diagnostic test to help guide treatment. (8),(10),(11).

Multiple modalities for assessing myocardial perfusion include resting only (without vasodilators), pre-exercise phase with vasodilators (Adenosine, Dipirydamol, Regadenoson), followed by stress-rest, and vice versa. All images during the exercise and rest periods allow the assessment of fixed and reversible perfusion defects. In the assessment of myocardial perfusion by CT, according to the consensus of the American Heart Association in 2020, the assessment of myocardial perfusion defects is assessed visually by the American Heart Association's 17-partition model: a) Severity: whether hypoperfusion is present (binary). b) Size: The size of the perfusion defect area (small, moderate, or large) as well as the transmural (>50%) or non-transmural (<50%) perfusion defect. The transmural perfusion ratio (TPR) was calculated by dividing the mean HU concentration in the subendocardial area by the subendocardial HU density. In the mean epicardial, if TPR < 1 is abnormal, if TPR < 0.75, is highly suggestive of myocardial ischemia. c) Reversibility. According to the recommendations of the American Heart CT Society 2020, perform myocardial perfusion assessment in combination with contrast-enhanced CT angiography for patients with a high risk of ischemic heart disease, known coronary artery disease, and intervention previously, moderate coronary artery stenosis, significant coronary calcification. (8),(10),(11).

Spectral CT provides good results in assessing myocardial perfusion compared to imaging methods considered gold standards, such as cardiac MRI and SPECT. According to Meinel et al., compared with SPECT, the CT spectrum is capable of assessing myocardial perfusion with a sensitivity of 92% and a specificity of 98% if only the resting phase is performed (rest scan), and if it is performed both the stress scan combined with the resting phase (rest scan) and the late enhancement phase (Late Enhancement), the accuracy increased significantly: sensitivity 99% and specificity 97%. These results suggest that CT spectroscopy to evaluate myocardial perfusion during rest and exercise should be considered the first choice for myocardial perfusion study. (8),(11)

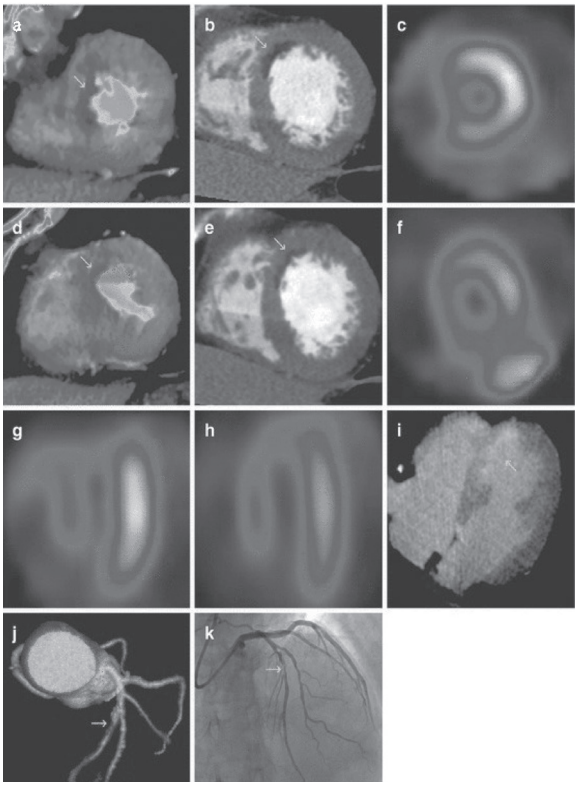


Figure 2.1. Myocardial necrosis in a 68-year-old male patient. Cardiovascular risk factors: dyslipidemia. History of gastritis, acute chest pain with negative cardiac enzymes and normal ECG. In 2010, the patient had a SPECT performed which showed normal results. The patient continued to have chest pain. A dual-energy CT scan with exercise and rest mapping iodine color and grayscale at 70 keV shows a fixed subendocardial perfusion defect in the anterior wall of the septum (arrows)(a,b,d,e).). Exercise–rest SPECT imaging also had similar findings (c, f). SPECT image at exercise and at rest in a four-chamber view from

the apex shows a fixed defect in the anterior septum (g,h). Two-energy CT image in late enhancement: shows enhancement of the anterior wall corresponding to the area of myocardial necrosis (arrow) (i). Three-dimensional reconstruction of the coronary tree shows severe LAD stenosis. in paragraph 7 (arrow) (j) and similar invasive coronary angiography (k). (Source: Carrascosa, P. M., & Cury, R. C. (2015) Myocardial Perfusion by Dual Energy CT. Dual -Energy CT in Cardiovascular Imaging.) (8)

2. Diagnosis of myocardiopathy

Delayed Myocardial Enhancement is considered a marker of myocardial fibrosis or scarring and is an essential feature in the assessment of MI and myocardial survival and in the evaluation of cardiomyopathy not due to ischemia. (12)

Compared with cardiac MRI, considered the gold standard in evaluating late contrast enhancement, CT spectrum has a sensitivity of 72-77% and a specificity of 88-92% in the evaluation of older MI, which is significantly higher than conventional CT images. In addition, late contrast enhancement on the CT spectrum can also detect non-ischemic cardiomyopathy. (12)

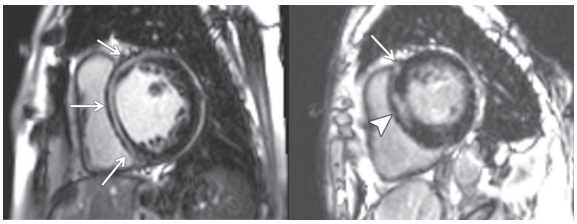


Figure 2.2. Late contrast enhancement in the mid-myocardium in patients with dilated cardiomyopathy and late contrast in the interventricular septum and biventricular junction in patients with hypertrophic cardiomyopathy. (Source: Ohta, Y. et al. (2018) Myocardial delayed enhancement CT for the evaluation of heart failure: comparison to MRI Radiology, 288(3), 682-691.)(12)

3. Diagnosis of acute myocarditis.

Spectral CT is a new technique for diagnosing acute myocarditis based on late iodine enhancement. In a study that compared with cardiac MRI in the diagnosis of acute myocarditis, it was found that spectral CT had a very high sensitivity of 100% based on patient analysis and a sensitivity of 82% for region-specific comparisons of 99%, positive predictive value 94%, negative predictive value 95%, and the concordance between these two methods is very high, with Kappa coefficient = 0.84. (13)

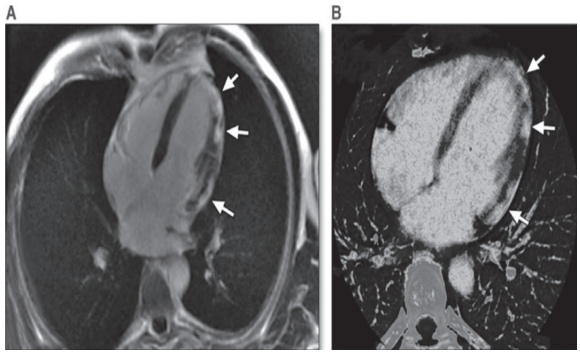


Figure 2.3. Late administration of gadolinium (Late Gadolinium Enhancement) in a 4-chamber view on cardiac MRI shows subepicardial myocarditis in the lateral wall and left ventricular apex (A). Similarly, the CT spectrum shows late enhancement with Iodine (B). (Source: Adeboye, A. et al. (2022). A review of the role of imaging modalities in evaluating viral myocarditis with a special focus on COVID-19-related myocarditis. Diagnostics, 12(2), 549.) (14)

4. Removal of calcifications in the assessment of atherosclerosis causing coronary stenosis

The monochromatic analysis allows anatomical visualization at energies ranging from 40 to 140 keV. Different grades show luminosity and atheroma with different intensities, areas, and volumes. With spectroscopic computed tomography, the artifact due to calcification was significantly reduced. (15)

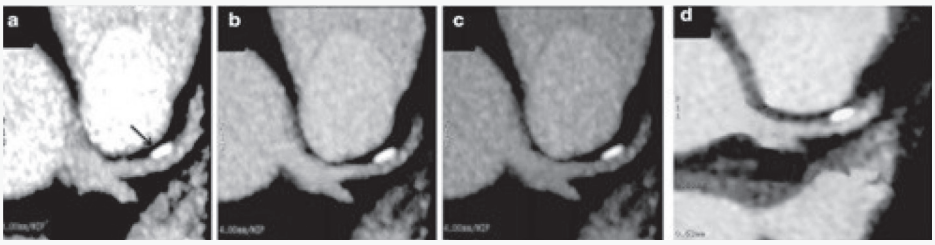


Figure 2.4. Dual-energy CT: atheroma with calcification proximal to LAD, large plaque at 40keV (a), a smaller plaque at 60keV (b), and atheroma further reduced in size at 80keV (c). On one-energy CT: atheroma with calcifications equal in size to that of 60keV (d). (Source: Carrascosa PM, Cury RC. Dual-Energy CT in Cardiovascular Imaging. 2015:173-230.)(15)

5. Diagnosis of high-risk plaque

High-risk plaque (HRP) was formerly known by another term vulnerable plaque.(16) Data from recent coronary CT studies described HRP features that are associated with an increased likelihood of future acute coronary syndromes and ischemia. HRP features include positive remodeling, low-density plaque, microcalcifications, and a donut-shaped sign (Napkin's ring).(16) These atheroma features are detected by Intravascular echocardiography and histological features of advanced atherosclerotic plaque and thin-encapsulated atherosclerotic plaque, potentially progressing to atheroma rupture/ thrombosis. (16)

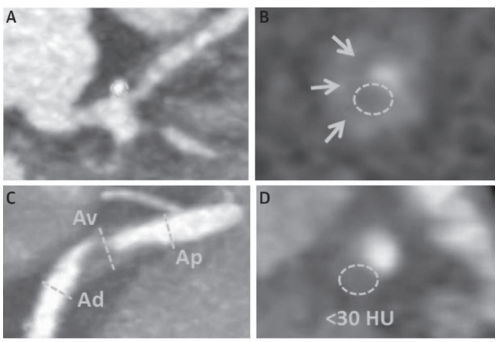


Figure 2.5. Types of high-risk atherosclerotic plaques. A: Spotty calcification. B: Napkin-ring sign. C: Positive remodeling. D: Low density (< 30 HU). (Source: Cury, R. C. et al. (2022). Cardiovascular Imaging, 15(11), 1974-2001.)(16)

6. Assessment of coronary stents after intervention

Computed tomography (CT) is a noninvasive diagnostic method that helps evaluate the lumen of the stent through the recognition of clear contrast material in the lumen downstream of the stent. (17)

However, this may be limited for stents that are small in size or contain a lot of metal due to the blurring phenomenon (Blooming artifact). Thanks to the CT spectrum scanner and the incident X-ray photon energy level adjustment, we can remove the stent or calcification to investigate whether the stent is blocked. The software of the CT spectrum machine has a pair of Calcium and Iode. When scanning, it can remove Calcium and get an Iode signal. (17)

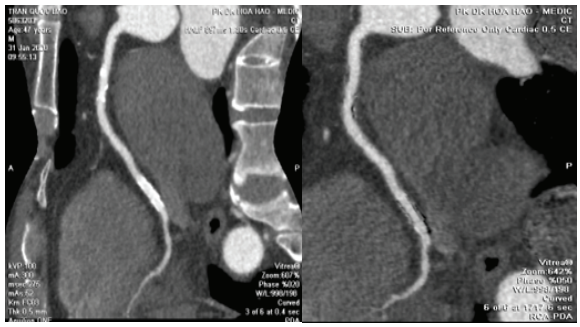


Figure 2.6. RCA distal stent, after stent removal and calcium, clearly see and evaluate the stent lumen. (Source: TTYK Medic 2021).

7. Detecting Graft stent endoleak in the aorta

Spectral CT also plays an important role in evaluating the endoleak after the stenting of the aorta in patients with aortic dissection, which is difficult for conventional CT because of the effects of metal artifacts and patient exposure to high radiation. Spectral CT provides virtual non-contrast images from arterial or venous phase data and thus reduces radiation exposure by nearly 50%. Phased venous CT angiography and virtual non-contrast datasets have been evaluated in multiple studies for patients following the repair of an aortic aneurysm. Algorithms are helpful for the fast and accurate evaluation of two-energy aortic data: virtual non-contrast images, iodine maps, and hard plaque algorithms are used to distinguish between Iodine and calcium. (18)

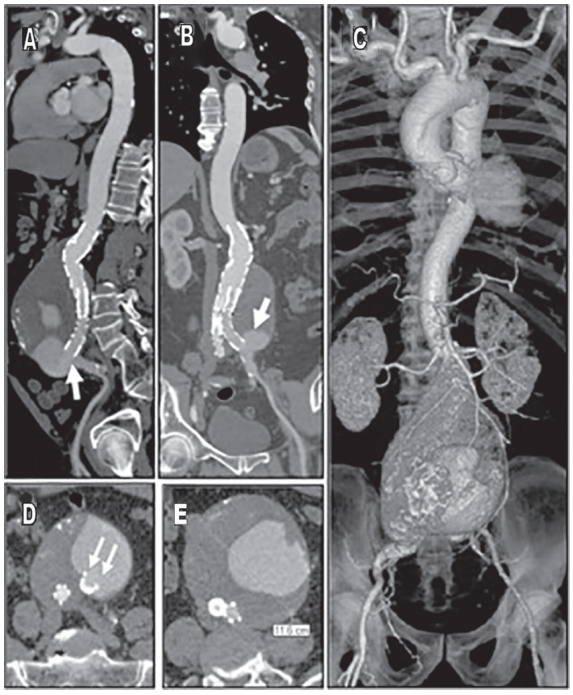


Figure 2.7. MDCT 320 showing a leaky abdominal aortic stent (arrow) (Source: Kassem TW. The Egyptian Journal of Radiology and Nuclear Medicine. 2017;48(3):621-6.)](19)

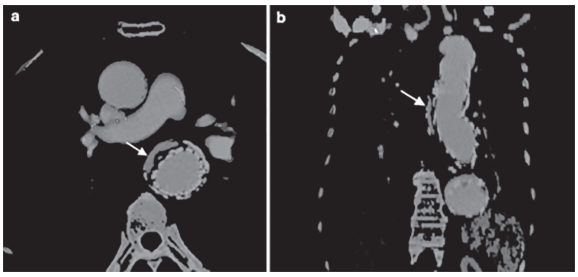


Figure 2.8. Axial (a) and coronal (b) slices show that Iodine (blue) is detected in the aneurysm and outside the Graft Stent. This corresponds to a type I endovascular fistula derived from the distal end of the Stent Graf. (Source: Sommer WH. Aorta Dual Energy CT in Clinical Practice. 2011:61-6.)(18)

8. Diagnosis of pulmonary embolism

Spectral CT of pulmonary arteries shows pulmonary embolism in the major branches, the segmental or subsegmental branches, and the corresponding hypoperfusion area on the coding image colorimetry. (20) Lysdahlgaard, S., Hess, S., Gerke, O., et al., in a comparative study between computed tomography and perfusion scintigraphy (V/Q Scan) published in the European Radiology journal, showed that the sensitivity, specificity, positive predictive value and negative predictive value of CT spectrum were 94.2% (95% CI, 88.3–100%), respectively 88.5% (95% CI, 81.3–95.6%), 87.8% (95%CI, 80.3–95.4%) and 94.5% (95%CI, 89.3–99.7%). (18)

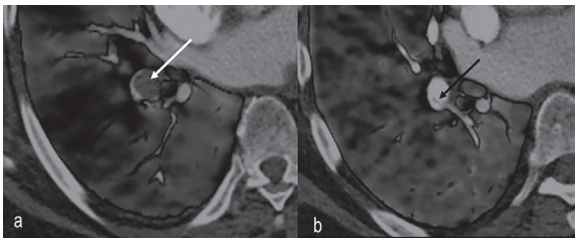


Figure 2.9. Image of pulmonary artery thrombosis. Initial evaluation with dual-energy CT shows a right lower lobe embolism (arrow) with pulmonary peripheral perfusion defect (a). Photographs taken

14 months later revealed that the embolus had almost completely disappeared but with some residual vascular defect (b). (Source: Vlahos, I. et al (2022). Dual-energy CT in pulmonary vascular disease. The British Journal of Radiology, 95(1129), 20210699.).(20)

9. Diagnosis of cardiac tumor

Although space-occupying lesions (thrombus or tumors) in the heart are uncommon, they carry a high risk of embolism, so an accurate and timely diagnosis is essential. Differentiating cardiac tumors from cardiac thrombosis is essential because of different treatment strategies. Spectral CT and MRI are good diagnostic tools. (21) According to Yoo Jin Hong et al., in a study analyzing the characteristics: of HU (CT attenuation value) of the mass during the arterial and late phase as well as Iodine concentration (mg/ml) on dual-energy CT and signal intensity ratio (SI) on cardiac MRI of intracardiac thrombus, cardiac tumor to evaluate the diagnostic value of dual-energy CT to differentiate between cardiac tumor and thrombosis. When Iodine concentration was used to differentiate between thrombosis and cardiac tumor, the optimal cut-off value for Iodine concentration for discriminating between thrombosis and heart tumor was 2.55 mg/ml, with a sensitivity of 66.7% and specificity of 79%. The area under the ROC curve of iodine concentration (mg/ml) was 0.77 (95%CI: 0.63-0.91) higher than the area under the ROC curve of HU concentration after injection. The contrast was 0.51 (95%CI: 0.34-0.69), and there was a statistically significant difference between the area under the ROC curve of iodine concentration and HU concentration after contrast injection $p < 0.001$ (AUC: -0.38, 95%CI: −0.49 – −0.27, $p < 0.001$) and the area under the ROC curve of the SI ratio on cardiac MRI is 0.89 significantly higher than the area under the ROC curve of iodine concentration (AUC; 0.77 vs. 0.89; $p = 0.04$). (21)

Table 2.1. Differences Between Heart Tumor and Thrombosis [21]

	Cardiac tumor (n=24)					Thrombosis (n=19)	P
	Lymphoma (n=4)	Metastasis (n=5)	Myxoma (n=9)	Other tumors* (n=6)	All		
Volume (cm^3)	32,14 ± 8,77	36,5±7,84	24,24 ± 5,84	9,89 ± 7,16	24,52 ± 3,76	3,98 ± 4,22	<0,001
attenuation HU	94,63 ± 21,1	88,6 ± 18,88	74,11±14,08	44,02 ±17,24	73,03 ±8,78	74,5 ± 9,87	0,912
Iodine concentration (mg/ ml)	3,04 ± 0,58	2,96 ± 0,52	3,33 ± 0,39	2,43 ± 0,47	2,98 ± 0,23	1,79 ± 0,26	0,002
SI ratio	4,13 ± 2,76	3,31 ± 3,39	10,3 ± 1,95	5,92 ± 2,14	6,9 ± 0,12	1,43 ± 0,14	0,008

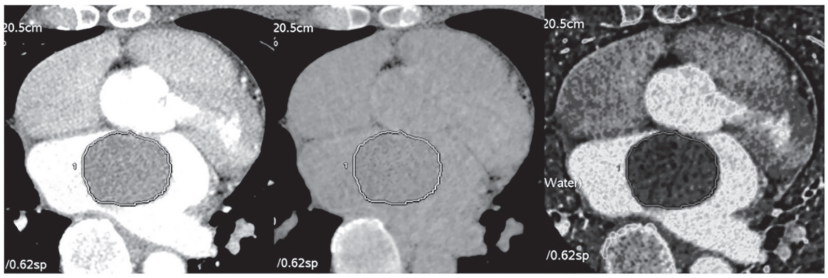


Figure 2.10. Quantitative analysis image on dual energy CT of the heart tumor. (A) 70keV monochromatic image represents the post-contrast CT image, (B) the de-Iodine image represents the pre-contrast CT image, and (C) the Iodine panel image. (Source: Hong, Y. J. et al. (2018). Scientific reports, 8(1), 15334.)(21)

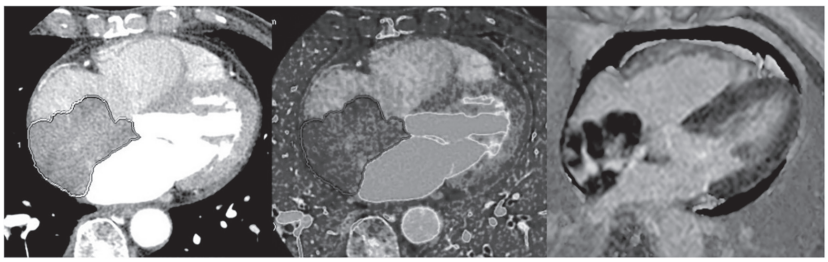


Figure 2.11. Right atrial lymphoma. (a) Contrast-enhanced spectral CT shows a 68 mm x 48 mm multilobed mass in the right atrium. Volume 47.1cm^3, density 70HU, (b) Iodine chart showing that Iodine concentration in this volumetric volume (VOI) is 1.67mg/ml, (c) Cardiac MRI 3 days later, start contrast agent late (LGE) showed this mass with increased central enhancement, SI ratio of 4.16, small pericardial effusion. (Source: Hong, Y. J. et al. (2018). Scientific reports, 8(1), 15334.)(21)

10. Investigation of left atrial thrombosis and mapping of anatomical correlation before atrial fibrillation ablation

In a study of 63 patients, 13 thrombosis and 19 cases of spontaneous echogenicity or spontaneous echo contrast (SEC) were detected by esophageal echocardiography (SATTQ). Using SATTQ as a reference standard, the sensitivity, specificity, positive predictive value, and negative predictive value of two-energy cardiac CT in detecting thrombosis and SEC in the left atrial appendage were respectively 97%, 100%, 100%, and 97%. (22)

Table 2.2. Comparison of Iodine and Blood Densities and Differences in Densities between the Regions of the LAA Thrombi and Pectinate Muscles and their Respective LAA Cavities in Patients with and without LAA Thrombi (He Y-Q, Liu L, Zhang M-C, Zeng H, Yang P. Dual-Energy Computed Tomography-Enabled Material Separation in Diagnosing Left Atrial Appendage Thrombus. Texas Heart Institute Journal. 2019;46(2):107-14.)(22)

	Group 1 (n=12)			Group 2 (n=12)			
Variable	LAA Cavities (mg/cm^3)	Pectinate Muscles (mg/cm^3)	*P* Value	LAA Cavities (mg/cm^3)	LAA Thrombi (mg/cm^3)	*P* Value	*P* Value*
Blood density	1,047.53 ± 11.88	1,002.37 ± 20.6	<0.001	1,046.74 ± 10.68	1,036.25 ± 24.87	0.192	0.001
Iodine density	16.64 ± 3.06	5.74 ± 2.4	<0.001	16.96 ± 4.83	1.77 ± 1.53	<0.001	<0.001
Blood-density differences	—	41.28 (34.5–47.69)	—	—	9.55 (–0.08 to 23.84)	—	0.003
Iodine-density differences	—	10.74 ± 2.14	—	—	15.19 ± 4.65	—	0.006

LAA = left atrial appendage

*LAA thrombi vs pectinate muscles

The blood-density differences were calculated by subtracting the blood densities in the central regions of the LAA pectinate muscles and thrombi from those of their respective LAA cavities for every slice. The iodine-density differences were calculated by subtracting the iodine densities in the central regions of the LAA pectinate muscles and thrombi from those of their respective LAA cavities for every slice.

Data are presented as mean ± SD or as median (25th–75th percentile). *P* <0.05 was considered statistically significant.

Spectral CT helps differentiate between left atrial thrombosis and pectinate muscle in the atrium, reconstructs the anatomy of the left atrium and pulmonary veins, and integrates CT images with electrophysiological maps, guiding for isolating pulmonary veins in atrial fibrillation ablation.

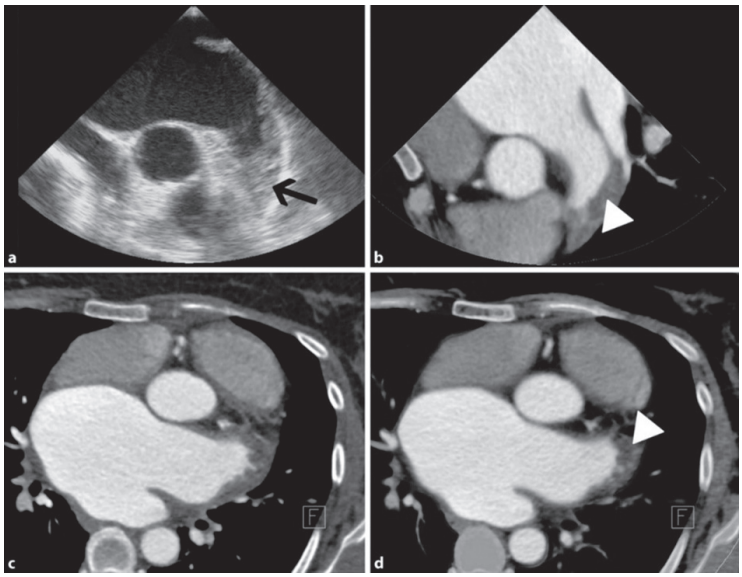


Figure 2.12. Dual-energy CT and SATTQ in a patient with left atrial appendage thrombosis. Thrombosis identified by transesophageal echocardiography; (a, arrow) and corresponding spectral CT images (b, arrowhead). Axial CT spectral images of the same patient show thrombus in the left atrium (c and d, arrows) (Source: Schlett, C. L., Heidt, M. C. et al. (2020). Mehrwert der Dual- Energy-Computertomographie zur Detektion von Thromben des linken Vorhofohrs Der Radiologe, 60(12).)(24)

III. CONCLUSION

The advent of spectral computed tomography that distinguishes materials with different effective atomic numbers has created many clinical applications. Spectral computed tomography is an imaging tool to investigate the degree of coronary stenosis and has a hemodynamic significance in examining myocardial perfusion as a functional diagnosis. Computed tomography (CT) scans help detect unstable plaques and predict the risk of acute cardiovascular events.

Computed tomography (CT) can be used as an initial diagnostic modality in patients at low or moderate risk for coronary artery disease.

Although magnetic resonance imaging remains the most optimal diagnostic modality for myocarditis and cardiomyopathies, spectral computed tomography can also diagnose these cases.

Investigating coronary stent restenosis or aortic stent Graft is also an advantage of spectral computed tomography.

The diagnosis of pulmonary embolism is based on the location of the embolized pulmonary artery, and the image of the lung parenchyma is evident and impressive with the color spectrum.

Computed tomography spectroscopy also helps to detect left atrial appendage thrombosis and create an electrophysiological map before atrial fibrillation; the radiation dose and the amount of contrast used in the patient are significantly reduced.

Abbreviation: HU: Hounsfield Units, SI: Signal Intensity, CT: Computed Tomography CTA: Computed Tomographic Angiography, MRI: Magnetic Resonance Imaging, DECT: Dual-energy computed tomography.

REFERENCES

1. Pim J de Feyter GPK, Filippo Cademartiri, Carlos van Mieghem, Bob Meijboom, Nico Mollet, Koen Nieman, Denise Vrouenraets. Computed Tomography of the Coronary Arteries. 2nd ed. CRC Press2008. 1-27 p.

2. Blankstein R. Cardiac Computed Tomography - Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine: Elsevier Inc.; 2022. 335-62 p.

3. Achenbach S, Ulzheimer S, Baum U, Kachelrieß M, Ropers D, Giesler T, et al. Noninvasive coronary angiography by retrospectively ECG-gated multislice spiral CT. Circulation. 2000;102(23):2823-8.

4. Achenbach S, Giesler T, Ropers D, Ulzheimer S, Derlien H, Schulte C, et al. Detection of coronary artery stenoses by contrast-enhanced, retrospectively electrocardiographically-gated, multislice spiral computed tomography. Circulation. 2001;103(21):2535-8.

5. Schoepf UJ. CT of the Heart: Humana Totowa, NJ; 2005. 45-332 p.

6. McCollough CH, Leng S, Yu L, Fletcher JG. Dual-and multi-energy CT: principles, technical approaches, and clinical applications. Radiology. 2015;276(3):637-53.

7. Kaza RK, Platt JF, Cohan RH, Caoili EM, Al-Hawary MM, Wasnik A. Dual-energy CT with single- and dual-source scanners: current applications in evaluating the genitourinary tract. Radiographics. 2012;32(2):353-69.

8. Carrascosa PM, Garcia MJ, Cury RC, Leipsic JA. Dual Energy CT: Springer; 2015. 3-246 p.

9. Rassouli N, Etesami M, Dhanantwari A, Rajiah P. Detector-based spectral CT with a novel dual-layer technology: principles and applications. Insights into imaging. 2017;8:589-98.

10. Danad I, Fayad ZA, Willemink MJ, Min JK. New applications of cardiac computed tomography: dual-energy, spectral, and molecular CT imaging. JACC: Cardiovascular Imaging. 2015;8(6):710-23.

11. Patel AR, Bamberg F, Branch K, Carrascosa P, Chen M, Cury RC, et al. Society of cardiovascular computed tomography expert consensus document on myocardial computed tomography perfusion imaging. Journal of cardiovascular computed tomography. 2020;14(1):87-100.

12. Ohta Y, Kitao S, Yunaga H, Fujii S, Mukai N, Yamamoto K, et al. Myocardial delayed enhancement CT for the evaluation of heart failure: comparison to MRI. Radiology. 2018;288(3):682-91.

13. Kalisz K, Halliburton S, Abbara S, Leipsic JA, Albrecht MH, Schoepf UJ, et al. Update on cardiovascular applications of multi-energy CT. Radiographics. 2017;37(7):1955-74.

14. Adeboye A, Alkhatib D, Butt A, Yedlapati N, Garg N. A review of the role of imaging modalities in the evaluation of viral myocarditis with a special focus on COVID-19-related myocarditis. Diagnostics. 2022;12(2):549.

15. Carrascosa PM, Cury RC. Dual-Energy CT in Cardiovascular Imaging. 2015:173-230.

16. Cury RC, Leipsic J, Abbara S, Achenbach S, Berman D, Bittencourt M, et al. CAD-RADS™ 2.0–2022 Coronary Artery Disease-Reporting and Data System: An Expert Consensus Document of the Society

of Cardiovascular Computed Tomography (SCCT), the American College of Cardiology (ACC), the American College of Radiology (ACR), and the North America Society of Cardiovascular Imaging (NASCI). Cardiovascular Imaging. 2022;15(11):1974-2001.
17. Bratke G, Hickethier T, Bar-Ness D, Bunck AC, Maintz D, Pahn G, et al. Spectral photon-counting computed tomography for coronary stent imaging: evaluation of the potential clinical impact for the delineation of in-stent restenosis. Investigative radiology. 2020;55(2):61-7.
18. Sommer WH. 2011. 61-90 p.
19. Kassem TW. Follow up CT angiography post EVAR: Endoleaks detection, classification and management planning. The Egyptian Journal of Radiology and Nuclear Medicine. 2017;48(3):621-6.
20. Vlahos I, Jacobsen MC, Godoy MC, Stefanidis K, Layman RR. Dual-energy CT in pulmonary vascular disease. The British Journal of Radiology. 2022;95(1129):20210699.
21. Hong YJ, Hur J, Han K, Im DJ, Suh YJ, Lee H-J, et al. Quantitative analysis of a whole cardiac mass using dual-energy computed tomography: comparison with conventional computed tomography and magnetic resonance imaging. Scientific reports. 2018;8(1):15334.
22. He Y-Q, Liu L, Zhang M-C, Zeng H, Yang P. Dual-Energy Computed Tomography-Enabled Material Separation in Diagnosing Left Atrial Appendage Thrombus. Texas Heart Institute Journal. 2019;46(2): 107-14.
23. Sharma K, Brinker JA, Henrikson CA. Computed tomography imaging in atrial fibrillation ablation. Journal of Atrial Fibrillation. 2011;4(1).
24. Schlett C, Heidt M, Jörg A, Soschynski M, Buss S, Korosoglou G, et al. Mehrwert der Dual-Energy-Computertomographie zur Detektion von Thromben des linken Vorhofohrs. Der Radiologe. 2020;60(12).

Renal denervation: Promising horizon from the latest data

Hieu Ba Tran [1]✉, Quang Ngoc Nguyen [1,2], Phong Dinh Phan [1,2], Hung Manh Pham [1,2]

[1] Vietnam National Heart Institute, Bach Mai Hospital

[2] Hanoi Medical University

ABSTRACT

Since the publication of the 2018 European Society of Cardiology/European Society of Hypertension (ESC/ ESH) Guidelines for the Management of Arterial Hypertension, several high - quality studies, including ran - domised, sham - controlled trials on catheter - based renal denervation (RDN) were published, confirming both the blood pressure (BP)-lowering efficacy and safety of radiofrequency and ultrasound RDN in a broad range of patients with hypertension, including resistant hypertension. RDN now is proposed as an adjunct treatment option in uncontrolled resistant hypertension, confirmed by ambulatory BP measurements, despite best efforts at lifestyle and pharmacological interven- tions. RDN may also be used in patients who are unable to tolerate antihypertensive medications in the long term. A shared decision-making process is a key feature and preferably includes a patient who is well informed on the benefits and limitations of the procedure. The decision-making process should take (i) the patient's global cardiovascular (CV) risk and/or (ii) the presence of hypertension-mediated organ damage or CV complications into account. Multidisciplinary hypertension teams involving hypertension experts and interventionalists evaluate the indication and facilitate the RDN procedure. Interventionalists require exper - tise in renal interventions and specific training in RDN procedures. Centres performing these procedures require the skills and resources to deal with potential complications. Future research is needed to address open questions and investigate the impact of BP-lowering with RDN on clinical outcomes and potential clinical indications beyond hypertension.

The review states the brief history of RDN, the broaden indication for RDN and the data over the time from the beginning of SYMPLICITY HTN 1 till to the update 2023.

Hypertensionisthemostcommoncardiovascular disorder in the community. According to the World Health Organization, in 2019, there were about 1.28 billion people with hypertension, and the global prevalence of this condition was 32% among adults aged 30-79. Hypertension was associated with 8.5 million deaths from stroke, coronary artery disease, peripheral artery disease, and kidney failure globally in 2016. Numerous studies have shown that well management of blood pressure can reduce cardiovascular events and mortality as well as all-cause mortality. However, the burden of uncontrolled hypertension (90%) remains

Correspondence to: Dr. Hieu Ba Tran. Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam. Email: tranhieu.vtm@gmail.com

a significant challenge worldwide, despite the availability of a wide range of antihypertensive drugs in various doses and combinations. Established causes for these challenges in achieving blood pressure control were potential side effects of drugs, difficulties in lifestyle modification, poor adherence to treatment; therefore, non-pharmacological approaches to replace or alleviate medical therapies are needed.

Several experimental studies on animal models have shown the importance of the renal sympathetic nervous system in regulating renal function and controlling cardiovascular function. Increased sympathetic activity has been demonstrated in individuals with hypertension, and recently, increased sympathetic activity in the renal system has also been observed in resistant hypertension patients. This observation and some previous research evidence have created the basics for applying therapeutic interventions using devices that interrupt sympathetic nerve signals in the renal system. The autonomic nervous system (sympathetic and parasympathetic) consists of a system of centripetal nerve fibers that transmit sensory signals from the periphery to the central nervous system (brain) and a system of centrifugal nerve fibers that transmit command signals from the central nervous system to organs and peripheral tissues to respond and reflexively react to changes received by the central nervous system from the periphery. Most of the centripetal nerve fibers of the kidney originate from the segment near the ureter, around the large blood vessels, and within the gland and smooth muscle layer of the kidney. In particular, most of these nerve fibers have a segment that surrounds the renal artery. It allows access via the renal artery to the distal renal parenchyma to ablate the nerve fibers, interrupting the signals of the sympathetic nervous system passing through here. The distribution of the centripetal nerves in the pelvic wall allows them to act as both stretch receptors and chemical reaction receptors, which, when stimulated by metabolites causing local anemia or uremic toxins, will stimulate nerve activity in the kidney. Stimuli perceived by peripheral receptors are transmitted through centripetal nerves to central regulatory structures. The level of activity of the renal sympathetic nervous system depends on the activity of sympathetic preganglionic nerve cells in the brainstem and lower medulla, including the lateral ventricle, the fourth ventricle, and the adjacent nuclei. Centrifugal nerves transmit signals from the brain to the kidney, primarily sympathetic nerves, releasing norepinephrine from the sympathetic nerve endings as an intermediary leading to renal vasoconstriction and reabsorption of sodium and water in renal tubular cells, as well as the release of renin from juxtaglomerular cells. With an understanding of the role of renal nerve fibers in regulating cardiovascular function through the three mechanisms mentioned above, scientists are focusing on studying the application of nervous system regulation and developing some interventions that impact this mechanism. Among them, renal denervation (RDN) based on a transcatheter approach has shown promising results.

A brief history of transcatheter renal denervation:

Since the 1950s, surgical sympathectomy of the abdominal ganglia has been performed to treat hypertension, with a 50% decrease in mortality rate in the group undergoing surgery compared to the control group. However, over time, with the emergence of various antihypertensive drugs and some consequences, such as erectile dysfunction, postural hypotension, and complications of open abdominal surgery, the technique is no longer performed.

In 2009, transcatheter renal denervation was

introduced and showed effectiveness in reducing blood pressure through the SYMPLICITY HTN-1,-2 trials conducted by Esler and colleagues. However, the results of the randomized, double-blind SYMPLICITY HTN-3 trial in 2014 did not demonstrate the superiority of RDN in blood pressure reduction compared to the control group after six months of follow-up. The negative results from the SYMPLICITY HTN-3 trial were a significant barrier to the widespread adoption of the technique in clinical practice, despite the factors that caused controversy, such as patient selection, medication adherence guidance, suboptimal procedure implementation, and the experience of performing denervation.

Twelve years after the SYMPLICITY HTN-3 trial, four critical studies on RDN, including the DENERHTN trial (28), SPYRAL HTN-OFF MED (36), and RADIANCE-HTN SOLO (37), demonstrated significant clinical and persuasive efficacy of ambulatory blood pressure compared to control groups in both hypertensive patients on antihypertensive medication and those who have not used antihypertensive medication. These landmark studies consider essential data for many cardiovascular societies worldwide to acknowledge renal denervation as one of the treatment methods for hypertension by devices at various levels of recommendation and consensus, in addition to medical treatment and lifestyle changes.

Indication for renal sympathetic denervation (RDN) in 2023:

Before the year of 2014, RDN was indicated for selected patients with resistant hypertension. However, from 2023, based on the results of some fundamental trials, the indications for RDN have been expanded to include the following patient populations in Figure 1.

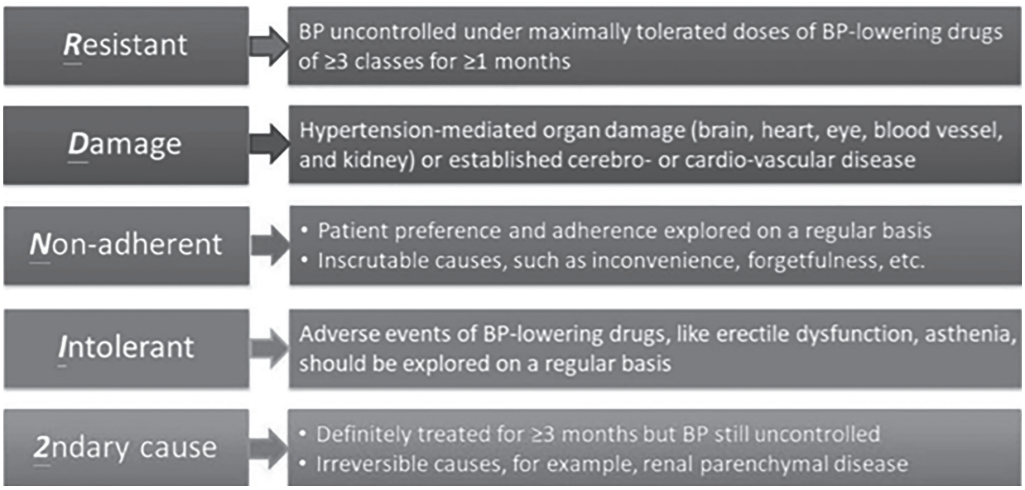


Figure 1. Emerging indications for RND

The recommended indications for renal denervation (RDN) are outlined in the 2021 American Heart Association Consensus, 2022 Asian Pacific Society of Cardiology, and 2022 Taiwan Society of Cardiology guidelines, as well as the latest 2023 European Society of Cardiology Clinical Practice Guidelines. Some RDN indications are categorized as IIa recommendations by certain reputable cardiovascular organizations.

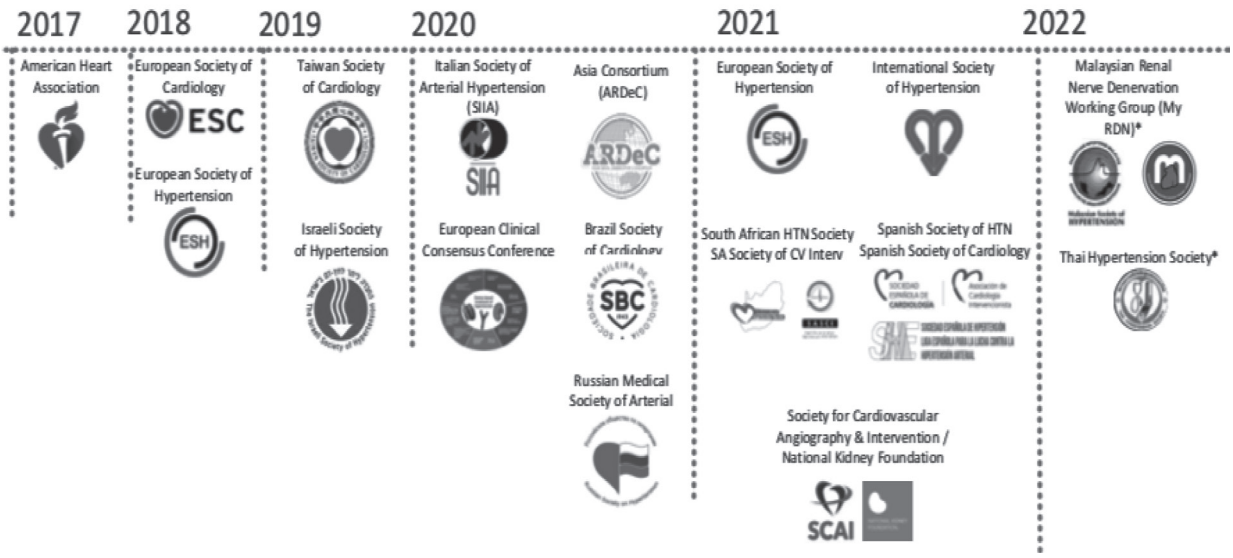


Figure 2. Cardiovascular societies recommend RDN over time

RDN has been proven effective in lowering blood pressure through some strongly convincing indicators such as: (i) The time to achieve the target for hypertension treatment is longer than that of the placebo; (2) Blood pressure-lowering efficacy (systolic or diastolic blood pressure measurement) in clinics, at home or on ; (3)24-hour ambulatory blood pressure monitoring. Among RDN candidates, the higher response rate was expected to achieve in hypertensives with at least one feature of ASCVD, atrial fibrillation, chronic kidney disease, type 2 diabetes or resistant hypertension. Moreover, for the first time, renal sympathetic nerve ablation has demonstrated independent efficacy in reducing cardiovascular events regardless of blood pressure-lowering efficacy.

Development of renal sympathetic nerve ablation systems:

Renal sympathetic nerve ablation through catheter-based techniques (RDN) can be achieved through radiofrequency (RF) energy, ultrasound waves, or by chemical materials such as injecting alcohol around the vessel through the catheter. The current RDN catheter systems are performed through the femoral artery and are compatible with 6 Fr or 7 Fr guiding catheter systems. The Catheter Symplicity Spyral (Medtronic®) system works by simultaneously delivering RF energy through four electrodes for 60 seconds. The Paradise system (Recor Medical®) consists of an electrode-carrying cylindrical ceramic tip within a distal balloon of the catheter and is designed to ablate circumferential and longitudinal-oriented renal sympathetic nerves using ultrasound energy. A minimum of two energy-delivering electrodes for 7 seconds each are performed in the main renal arteries, spaced longitudinally by 5mm due to uniform heating and depth of the effect. Other access systems for ablation, such as specialized catheters (Peregrine; Ablative Solutions®), deliver small, absolute doses of alcohol (0.6ml per renal artery) in situ to destroy the sympathetic nerve fibers around the outer layer of the renal artery. The catheter comprises three very small needles at the distal end of the guiding catheter in the main renal artery and is controlled from the outside handle.

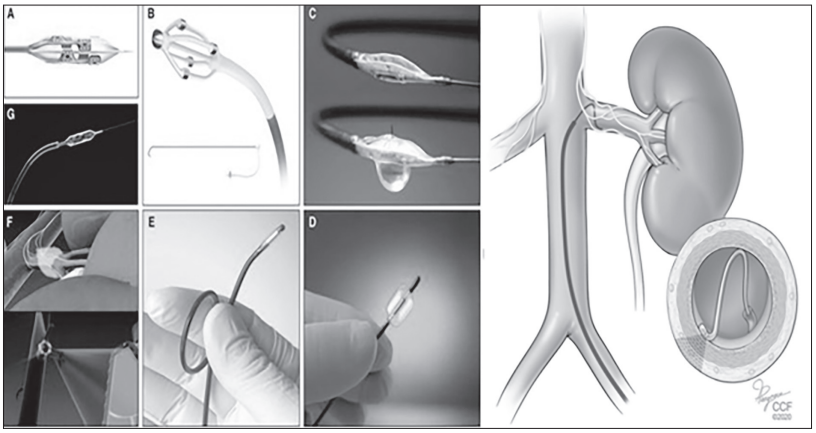


Figure 3. There are currently various RDN devices available to reduce sympathetic nerve activity in the kidney, thereby lowering blood pressure. The image on the right depicts the mechanism of denervating the centripetal and centrifugal nerve fibers surrounding the renal artery. These devices include A, the Boston Scientific V2 Renal Denervation System; B, the St. Jude Medical multi-electrode RDN system; C, the MedSystems mapping-based ablation system; D, the ReCor Medical PARADISE system for transdermal sympathetic denervation; E, the ultrasound-based sympathetic denervation system; F, the Kona Medical system for acoustic-based sympathetic denervation; and G, the Covidien-Maya balloon-based denervation system.

However, histological studies have shown that energies with a penetration depth of >7mm will have a 90% or greater effect on destroying sympathetic nerve fibers around the renal artery. Although sympathetic nerve fibers around the renal artery near the origin are more abundant, they tend to be farther from the diameter of the renal artery; therefore, it is necessary to target more points further away and disrupt the branches after the bifurcation of renal arteries.

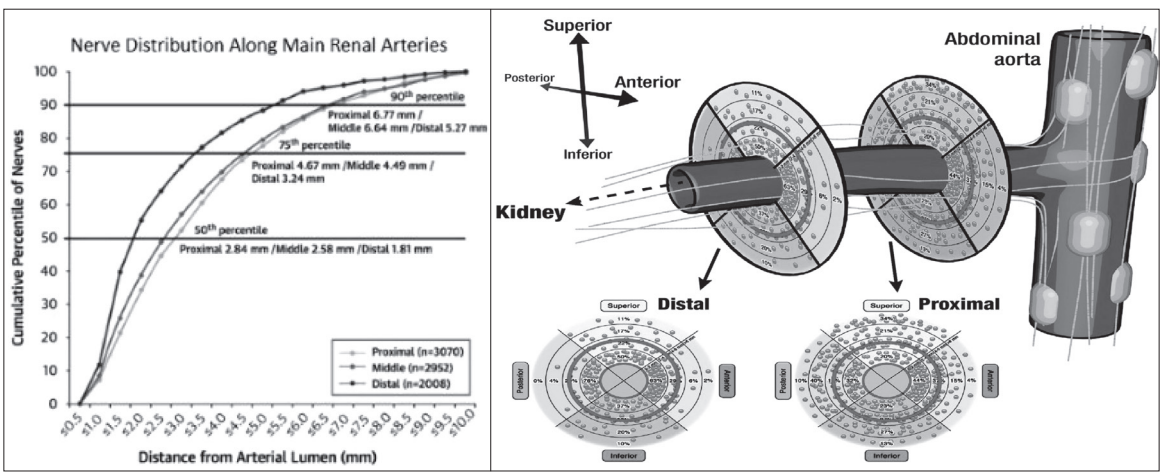


Figure. Schematic illustration of the renal artery with its surrounding nerves. The sympathetic nerve fiber from the abdominal ganglia and run conically to the distal part of the vessel. The lower circles show the nerve distribution stratified according to the total number (each green dot represents ten nerves) and relative number (as percent per segment) of nerves.

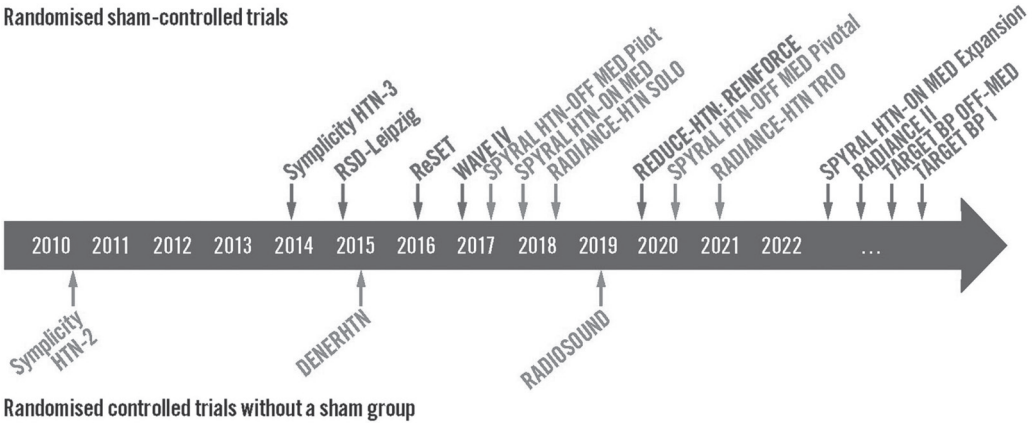


Figure. Overview of important randomized controlled trials with (top) and without (bottom) an invasive sham-control group. Green indicates that the trial met its primary efficacy outcome; red indicates that the trial did not meet its primary efficacy outcome.

A series of new trials have been conducted based on a more rigorous study design using next-generation sympathetic nerve ablation devices. In addition, a new research direction is to investigate the effectiveness of renal denervation (RDN) in patients with hypertension who are not (yet) taking medication to prove or refute the hypothesis that RDN reduces blood pressure in difficult-to-control hypertension without antihypertensive drug intervention (OFF-MED pilot study). Another clinically relevant research direction is to study RDN in patients using standardized antihypertensive drugs (ON-MED trial) to evaluate whether RDN can further reduce blood pressure and decrease the number of medications required to control blood pressure. In both trials, analyses of adverse effects and toxicity are used to ensure compliance with study protocols.

The SPYRAL HTN-OFF MED and SPYRAL HTN-ON MED trials are designed to study feasibility (not intended to assess primary effectiveness or safety) by randomizing patients with combined systolic-diastolic hypertension (Systolic BP: 150-179mmHg; Diastolic BP ≥ 90mmHg, and 24-hour BP: 140-169mmHg) who are either on medication (ON-MED) or not on medication (OFF-MED) and undergoing RDN using the Spyral ® multi-electrode radiofrequency (RF) energy emitting catheter or a sham procedure. In the HTN-OFF MED pilot study, analysis of over 80 initial subjects showed a significant reduction in 24-hour systolic blood pressure after RDN compared to the control group. On 24-hour ambulatory blood pressure monitoring, RDN sustainably lowered systolic and diastolic blood pressure both during the day and at night. Based on the evidence provided by these trial results, the pivotal trial (SPYRAL Pivotal) with a sham control procedure (SPYRAL HTN-OFF MED Pivotal) was conducted. The trial was further conducted to evaluate the primary criterion of whether RDN is effective in reducing ambulatory systolic blood pressure on 24-hour ambulatory blood pressure monitoring and clinic systolic blood pressure after three months of follow-up compared to before treatment. The designs of the two trials are similar, and data from the SPYRAL Pivotal trial (n=251) and the pilot study (n=80) were combined and analyzed using Bayesian algorithms. The results showed that both primary and secondary endpoints were achieved with a

posterior probability of superiority >0.999 in both trials. Ambulatory systolic blood pressure (reduced by 3.9 mmHg, 95% Bayesian credible interval -6.2 to -1.6) and office systolic blood pressure (reduced by 6.5 mmHg, 95% Bayesian credible interval -9.6 to -3.5) were significantly reduced in the treatment group (n=166) compared to the sham control group. The study did not report any major device-related or procedure-related adverse events within three months.

The RADIANCE-HTN SOLO trial was a randomized trial of 146 patients with combined elevated ambulatory systolic and diastolic blood pressure (24-hour ambulatory blood pressure of 135-169/85-104 mmHg). The trial achieved its primary endpoint, which was a significant reduction in ambulatory systolic blood pressure during the day (-6.3 mmHg, 95% CI -9.4 to -3.1, P<0.001) after two months of renal denervation (RDN) compared to the control group. RDN achieved sustainable blood pressure reduction on 24-hour ambulatory blood pressure monitoring, in-office blood pressure, and home blood pressure measurements for both systolic and diastolic blood pressure. No major adverse effects were reported in either group. The RADIANCE-HTN TRIO trial selected patients with uncontrolled hypertension despite the use of a recommended triple combination therapy reported in 2021 and achieved success in the primary efficacy endpoints.

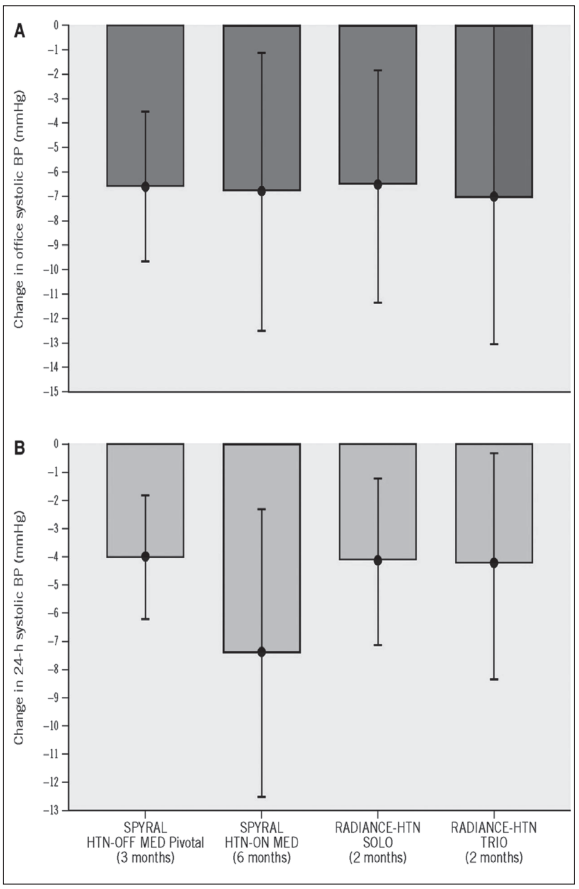


Figure. Mean BP change in second-generation sham-controlled RDN trials. Mean change in office (A) and 24-hour (B) systolic BP in second-generation sham-controlled RDN trials. The SPYRAL HTN-OFF MED Pivotal trial used a Bayesian design with an informative prior (outcome analyses included data from the pilot and pivotal trials). Data are mean and 95% confidence intervals (CI). BP: blood pressure.

In 2022, the long-term follow-up data from the SYMPLICITY HTN-3 trial showed the safety of the renal denervation (RDN) procedure up to 36 months after the intervention. From 12 to 36 months after the procedure, patients who underwent RDN had significantly greater blood pressure reduction and better blood pressure control than those who underwent sham intervention. Around 1400 patients with resistant hypertension were included in the trial, of whom 535 were randomized to RDN (n=364) or sham intervention (n=171). After assessing the primary outcome at six months, eligible patients in the sham group could cross over to receive RDN and were called

the crossover group. After 36 months of follow-up, there were 219 patients from the initial RDN group, 63 patients from the crossover group, and 300 patients in the sham/uncrossed-over group. Results showed significant reductions in office systolic and diastolic blood pressure, 24-hour ambulatory blood pressure, and daytime and nighttime blood pressure in the RDN group compared to the control group. The composite safety endpoint at 48 months, including all-cause mortality, new onset end-stage renal disease, major cardiovascular events leading to target organ damage, vascular complications, renal artery interventions, and hypertensive emergencies, was 15% in the RDN group, 14% in the crossover group, and 14% in the control group. This is the longest safety analysis of RDN in a randomized trial and highlights the overall safety of the procedure.

With the use of RDN techniques, the response of patients to blood pressure reduction varies considerably, and 20 to 30% of patients experience a non-significant reduction in blood pressure (above the mean level). The issue of patient response to blood pressure reduction with RDN remains a clinical concern that needs to be further investigated. Some factors that may be associated with RDN response are mentioned, such as age, gender, weight, and comorbidities, but no significant factors have been identified. The correlation between the severity of hypertension (very high blood pressure readings) and the degree of blood pressure reduction achieved is the most widely reported, although the relationship is not yet clear. In the SPYRAL HTN-OFF MED trial, an initial heart rate of 73.5 beats per minute, which is higher than the average, was found to be significantly associated with a decrease in systolic and diastolic blood pressure compared to the average decrease (-10.7/-7.5 mmHg; P = 0.001), while the reduction in blood pressure in patients with a lower heart rate was not significant. Therefore, heart rate may predict patient response to RDN procedures.

In conclusion, the latest data from several landmark studies are important and able to convince many cardiovascular associations worldwide to recognize renal sympathetic denervation as one of the treatment methods for hypertension using devices at different recommended levels, in addition to medical treatment and lifestyle changes, create new horizon to effectively manage huge cardiovascular problems in community such as hypertension.

REFERENCES

1. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 coun- tries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet.* 2020;396:1223-49.
2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet.* 2021;398:957-80.
3. Ettehad D, Emdin CA, Kiran A, Anderson SG, Callender T, Emberson J, Chalmers J, Rodgers A, Rahimi K. Blood pressure lowering for prevention of cardiovascular dis- ease and death: a systematic review and meta-analysis. *Lancet.* 2016;387:957-67.
4. Bundy JD, Li C, Stuchlik P, Bu X, Kelly TN, Mills KT, He H, Chen J, Whelton PK, He J. Systolic Blood Pressure Reduction and Risk of Cardiovascular Disease and Mortality: A Systematic Review and Network Meta-analysis. *JAMA Cardiol.* 2017;2: 775-81.

5. Aggarwal R, Chiu N, Wadhera RK, Moran AE, Raber I, Shen C, Yeh RW, Kazi DS. Racial/Ethnic Disparities in Hypertension Prevalence, Awareness, Treatment, and Control in the United States, 2013 to 2018. *Hypertension.* 2021;78:1719-26.
6. Egan BM, Li J, Sutherland SE, Rakotz MK, Wozniak GD. Hypertension Control in the United States 2009 to 2018: Factors Underlying Falling Control Rates During 2015 to 2018 Across Age- and Race-Ethnicity Groups. *Hypertension.* 2021;78:578-87.
7. Lauder L, Azizi M, Kirtane AJ, Böhm M, Mahfoud F. Device-based therapies for arterial hypertension. *Nat Rev Cardiol.* 2020;17:614-28.
8. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, Kahan T, Mahfoud F, Redon J, Ruilope L, Zanchetti A, Kerins M, Kjeldsen SE, Kreutz R, Laurent S, Lip GYH, McManus R, Narkiewicz K, Ruschitzka F, Schmieder RE, Shlyakhto E, Tsioufis C, Aboyans V, Desormais I; ESC Scientific Document Group. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J.* 2018;39:3021-104.
9. Townsend RR, Mahfoud F, Kandzari DE, Kario K, Pocock S, Weber MA, Ewen S, Tsioufis K, Tousoulis D, Sharp ASP, Watkinson AF, Schmieder RE, Schmid A, Choi JW, East C, Walton A, Hopper I, Cohen DL, Wilensky R, Lee DP, Ma A, Devireddy CM, Lea JP, Lurz PC, Fengler K, Davies J, Chapman N, Cohen SA, DeBruin V, Fahy M, Jones DE, Rothman M, Böhm M; SPYRAL HTN-OFF MED trial investigators*. Catheter-based renal denervation in patients with uncontrolled hyper- tension in the absence of antihypertensive medications (SPYRAL HTN-OFF MED): a randomised, sham-controlled, proof-of-concept trial. *Lancet.* 2017;390:2160-70.
10. Kandzari DE, Böhm M, Mahfoud F, Townsend RR, Weber MA, Pocock S, Tsioufis K, Tousoulis D, Choi JW, East C, Brar S, Cohen SA, Fahy M, Pilcher G, Kario K; SPYRAL HTN-ON MED Trial Investigators. Effect of renal denervation on blood pressure in the presence of antihypertensive drugs: 6-month efficacy and safety results from the SPYRAL HTN-ON MED proof-of-concept randomised trial. *Lancet.* 2018;391:2346-55.
11. Böhm M, Kario K, Kandzari DE, Mahfoud F, Weber MA, Schmieder RE, Tsioufis K, Pocock S, Konstantinidis D, Choi JW, East C, Lee DP, Ma A, Ewen S, Cohen DL, Wilensky R, Devireddy CM, Lea J, Schmid A, Weil J, Agdirlioglu T, Reedus D, Jefferson BK, Reyes D, D'Souza R, Sharp ASP, Sharif F, Fahy M, DeBruin V, Cohen SA, Brar S, Townsend RR; SPYRAL HTN-OFF MED Pivotal Investigators. Efficacy of catheter-based renal denervation in the absence of antihypertensive medi- cations (SPYRAL HTN-OFF MED Pivotal): a multicentre, randomised, sham-con- trolled trial. *Lancet.* 2020;395:1444-51.
12. Azizi M, Schmieder RE, Mahfoud F, Weber MA, Daemen J, Davies J, Basile J, Kirtane AJ, Wang Y, Lobo MD, Saxena M, Feyz L, Rader F, Lurz P, Sayer J, Sapoval M, Levy T, Sanghvi K, Abraham J, Sharp ASP, Fisher NDL, Bloch MJ, Reeve-Stoffer H, Coleman L, Mullin C, Mauri L; RADIANCE-HTN Investigators. Endovascular ultra- sound renal denervation to treat hypertension (RADIANCE-HTN SOLO): a multicen- tre, international, single-blind, randomised, sham-controlled trial. *Lancet.* 2018;391: 2335-45.
13. Azizi M, Sanghvi K, Saxena M, Gosse P, Reilly JP, Levy T, Rump LC, Persu A, Basile J, Bloch MJ, Daemen J, Lobo MD, Mahfoud F, Schmieder RE, Sharp ASP, Weber MA, Sapoval M, Fong P, Pathak A, Lantelme P, Hsi D, Bangalore S, Witkowski A, Weil J, Kably B, Barman NC, Reeve-Stoffer H, Coleman

L, McClure CK, Kirtane AJ; RADIANCE-HTN investigators. Ultrasound renal denervation for hypertension resistant to a triple medication pill (RADIANCE-HTN TRIO): a randomised, multicentre, single-blind, sham-controlled trial. *Lancet.* 2021;397:2476-86.

14. Lauder L, da Costa BR, Ewen S, Scholz SS, Wijns W, Lüscher TF, Serruys PW, Edelman ER, Capodanno D, Böhm M, Jüni P, Mahfoud F. Randomized trials of inva- sive cardiovascular interventions that include a placebo control: a systematic review and meta-analysis. *Eur Heart J.* 2020;41:2556-69.

15. Kandzari DE, Mahfoud F, Weber MA, Townsend R, Parati G, Fisher NDL, Lobo MD, Bloch M, Böhm M, Sharp ASP, Schmieder RE, Azizi M, Schlaich MP, Papademetriou V, Kirtane AJ, Daemen J, Pathak A, Ukena C, Lurz P, Grassi G, Myers M, Finn AV, Morice MC, Mehran R, Jüni P, Stone GW, Krucoff MW, Whelton PK, Tsioufis K, Cutlip DE, Spitzer E. Clinical Trial Design Principles and Outcomes Definitions for Device-Based Therapies for Hypertension: A Consensus Document From the Hypertension Academic Research Consortium. *Circulation.* 2022;145:847-63.

16. Bhatt DL, Kandzari DE, O'Neill WW, D'Agostino R, Flack JM, Katzen BT, Leon MB, Liu M, Mauri L, Negoita M, Cohen SA, Oparil S, Rocha-Singh K, Townsend RR, Bakris GL; SYMPLICITY HTN-3 Investigators. A controlled trial of renal denervation for resistant hypertension. *N Engl J Med.* 2014;370:1393-401.

17. Veldhuisen DJ, Verma S, Voors AA, Wittes J, Zannad F, Zhang J, Seferovic P, Coats AJS. Conducting clinical trials in heart failure during (and after) the COVID-19 pandemic: an Expert Consensus Position Paper from the Heart Failure Association (HFA) of the European Society of Cardiology (ESC). *Eur Heart J.* 2020;41:2109-17.

18. Lauder L, Wolf MA, Scholz SS, Hohl M, Mahfoud F, Böhm M. Renal Denervation: Is It Ready for Prime Time? *Curr Cardiol Rep.* 2019;21:80.

19. Fengler K, Rommel KP, Blazek S, Besler C, Hartung P, von Roeder M, Petzold M, Winkler S, Hollriegel R, Desch S, Thiele H, Lurz P. A Three-Arm Randomized Trial of Different Renal Denervation Devices and Techniques in Patients With Resistant Hypertension (RADIOSOUND-HTN). *Circulation.* 2019;139:590-600.

20. Weber MA, Kirtane AJ, Weir MR, Radhakrishnan J, Das T, Berk M, Mendelsohn F, Bouchard A, Larrain G, Haase M, Diaz-Cartelle J, Leon MB. The REDUCE HTN: REINFORCE: Randomized, Sham-Controlled Trial of Bipolar Radiofrequency Renal Denervation for the Treatment of Hypertension. *JACC Cardiovasc Interv.* 2020;13: 461-70.

21. Knuuti J, Wijns W, Saraste A, Capodanno D, Barbato E, Funck-Brentano C, Prescott E, Storey RF, Deaton C, Cuisset T, Agewall S, Dickstein K, Edvardsen T, Escaned J, Gersh BJ, Svitil P, Gilard M, Hasdai D, Hatala R, Mahfoud F, Masip J, Muneretto C, Valgimigli M, Achenbach S, Bax JJ; ESC Scientific Document Group. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syn- dromes. *Eur Heart J.* 2020;41:407-77.

INTRODUCTION TO AUTHORS

Journal of Vietnamese Cardiology, publishing license number: 528/GP-BVHTT; ISNN code: 1859-2848, is the official scientific publication of Vietnam National Heart Association. The Journal is published quarterly and there is a yearly issue published in English

The Journal of Vietnamese Cardiology will publish articles that cover relevant Cardiology and related fields. The purpose of the Journal is to bring its readers important researchs, insightful articles, clinical cases and new perspectives in the current practice of Cardiology.

The content of the articles belongs to the author themselves and not to the Editorial Board or the publisher. The Editorial Board and the publisher are not responsible for the legal or ethical nature of the articles. When submitting articles, the authors must confirm in the manuscript sent to the editor: "I agree to transfer all copyrights to publish this article [article title] to the Vietnam National Heart Association and declare that the article is original, does not infringe any third party publishing or proprietary rights, has not been submitted to another journal, and has never been published."

Authors of articles submitted to the Journal of Vietnamese Cardiology must clearly state the sources of funding for the research (if any). The editorial board must be made aware of other organizations that may have copyright disputes (such as co-ownership, consulting, etc.).

Articles will be reviewed by two or more editors. Articles are accepted based on content, creativity and validity. If accepted for publication, editors can make edits to make the article clearer and easier to understand without changing the essence of the article.

The Journal will consist of the following categories:

- Original Article
- Review
- Newsletter
- Editorial
- Case Report

GENERAL REQUIREMENTS FOR MANUSCRIPT

The manuscript is written in Vietnamese or English (if submitted for the annual English issue), in Arial font (Unicode system), size 13, 1.5 lines spacing. Each article must not exceed 7 A4 pages, including tables, illustrations and references, references are cited in square brackets. Manuscripts must be clearly paginated.

The terms used in the article must be consistent with the Vietnamese Encyclopedia and the Vietnamese Nomenclature of Cardiovascular Disease published by the Vietnam National Heart Association (2003). Terms that are not included in the Nomenclature, if translated from a foreign language, must be accompanied by the original word. Abbreviations must be captioned.

The contact info must be displayed in the footer of the first page of the article, with the name of the main author of the article along with the contact address (mailing and email address).

RESEARCH ETHICS REQUIREMENT FOR MANUSCRIPTS

A manuscript is only accepted if its main author fulfills all the following:

a) The contents of the manuscript have not been published in whole or in parts in other journals;

(b) The manuscript has not been published in another journal;

(c) All authors have contributed significantly to the research or preparation of the manuscript and are jointly responsible for the contents of the manuscript;

(d) Adhere to research ethics safeguards (e.g., consent to participate in research) and the research must be approved by a reputable biomedical research ethics review board.

The authors also specify in the manuscript (Acknowledgements) the research funding agencies, the role of pharmaceutical companies, medical device companies, and other companies in supporting the research and commitment. conclusions about possible conflicts of interest related to the study.

SPECIFIC REQUIREMENTS FOR EACH ARTICLE TYPE

REVIEW

ARTICLE TITLE

(Short, concise but able to reflect the topic that is being reviewed, avoid abbreviations)

Author A, Author B, Author C **(order by contribution, from most to least)**

Organization Y, Organization X, Organization Z

Abstract: outlines the review topic, the objective of the article and references gathering, processing methods, research prospects and conclusion. The abstract must be written in one paragraph and should not exceed 200 words.

Keywords: illustrate the main problem that the research covers, maximum of 6 words or phrases.

INTRODUCTION

Clearly state the general problem and reason for the analysis, the meaning of the topic review, author's point of view and approach.

CONTENT

This can be divided into sub-sections depending on the author's point of view and approach, there should be statements regarding future research prospects of the reviewed topic. The author should prioritize papers published near the time of writing the review.

CONCLUSIONS

Clearly state what information the review accomplished in providing, whether the review's objectives were achieved and research prospects for further research on the topic.

REFERENCES

Each review article should have no more than 15 references according to the guidelines.

ABSTRACT (written in English)

English title, abstract (does not exceed 200 words), keyword translated from the original Vietnamese version.

RESEARCH ARTICLE (CLINICAL RESEARCH)

ARTICLE TITLE

(Short, concise but able to reflect the topic that is being reviewed, avoid abbreviations)

Author A, Author B, Author C (**order by contribution, from most to least**)

Organization Y, Organization X, Organization Z

ABSTRACT: illustrates the main findings and conclusion of the research. The abstract must be written in one paragraph and should not exceed 200 words.

Keywords: illustrate the main problem that the research covers, maximum of 6 words or phrases.

INTRODUCTION

Introduce research objectives in relation to other studies in the field, 1 A4-page long (about 500 words) and cite at least 5 references.

MATERIALS AND METHODS

Short, concise while still have adequate information so that the reader can comprehend the research process. New processes that have never been done before need to be described in detail and have reference citations. Clearly state that the IRB has approved the ethics of the research (if required).

RESULTS

Figures and tables are clearly presented with brief captions. Results that are not presented in tables can be described in paragraphs. The total number of tables and figures should not exceed 5. The scanned image must be in the correct position for illustration and accompanied by the original image.

DISCUSSIONS

Should not be longer than 2 typed pages, only contain discussion and explanations related to the obtained results.

CONCLUSIONS

Brief, concise. Do not relist the results of the research.

REFERENCES

- References are cited by number, not by author and publish year.
- References are collected and sorted by order of appearance in the article.
- References in foreign languages must be kept untranslated and untransliterated.
- Refrain from using theses, dissertations, textbooks and websites as references.
- Each article should have no more than 10 references.
- A reference must be presented as follows: full names of authors (if the author is a foreigner,

in order: full surname, middle name and initials.) Journal name, year of publication, volume (number): page If the article has more than one author, write only the names of the first three authors and associates.

ABSTRACT (written in English)

English title, abstract (does not exceed 200 words), keyword translated from the original Vietnamese version.

CASE STUDY ARTICLE (CLINICAL CASE)

ARTICLE TITLE

(Short, concise but able to reflect the topic that is being reviewed, avoid abbreviations)

Author A, Author B, Author C (**order by contribution, from most to least**)

Organization Y, Organization X, Organization Z

ABSTRACT: depicts the context of case detection, briefly introduce the process of detection, diagnosis, treatment and results. The abstract must be written in one paragraph and does not exceed 200 words.

Keywords: illustrate the main problem that the research covers, maximum of 6 words or phrases.

BACKGROUND

Introduce the social and historical context of the case for the readers to understand the benefits of knowing the case information.

CASE INTRODUCTION

Describe the circumstances in which the case was discovered, plans, management and treatment procedures and treatment results.

DISCUSSIONS

Should not be longer than 2 typed pages, explain in detail the circumstances of the case and the obtained results.

CONCLUSIONS

Brief, concise. Do not relist the results of the research.

REFERENCES

In accordance with the guidelines for presenting research paper results.

ABSTRACT (written in English)

English title, abstract (does not exceed 200 words), keyword translated from the original Vietnamese version.

Thank you for your collaboration.

Editorial Board – Journal of Vietnamese Cardiology