INFLUENCE OF CAROTID INTIMA MEDIA THICKNESS ON THE PATIENT'S MEMORY FUNCTION FAILS HEART WITH EJECTION FRACTION LEFT VENTRICLE DESCENDS

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ABSTRACT

Heart failure (HF) with reduced left ventricular ejection fraction (LVEF) is frequently associated with cognitive decline, including memory impairment. This study investigates the relationship between carotid intima-media thickness (CIMT), a marker of subclinical atherosclerosis, and specific memory domains immediate, recall, and recognition in patients with reduced LVEF. A cross-sectional study was conducted on 52 HF patients at Prof. Dr. R.D. Kandou Hospital. Memory function was assessed using the Word List Memory Test, and CIMT was measured via carotid ultrasound. Regression analysis showed that increased CIMT in the left common carotid artery (CCA Sinistra) was significantly associated with lower immediate and recognition memory performance. Furthermore, elevated CIMT in both carotid arteries was negatively correlated with recall memory. These findings highlight a potential vascular contribution to cognitive impairment in HF patients, suggesting that subclinical carotid atherosclerosis may impair cerebral perfusion. The study provides clinical insight into the importance of vascular assessment in managing cognitive health in HF populations. Early detection of carotid pathology may offer a strategy to prevent or reduce cognitive decline in these patients.

KEYWORDS	*heart failure, left ventricular ejection fraction, carotid intima media thickness, memory function, cognitive impairment*

INTRODUCTION

Heart failure (*Heart Failure* / HF) can be defined as a condition in which the heart is unable to pump enough blood to the body's tissues. Impaired heart function can manifest as impaired diastolic or systolic function, or both, impaired heart rhythm, or a mismatch of preload and afterload. Heart failure is the worst final manifestation of almost all heart diseases, ranging from coronary heart disease, hypertensive heart disease, heart valve abnormalities, congenital heart disease, cardiomyopathy, and other heart diseases. This condition can lead to death (Aladin et al., 2021; De Anda-Duran et al., 2022; Dias et al., 2012; Effoe et al., 2014; Engström et al., 2009).

The classification of heart failure by left ventricular ejection fraction (FEVKi) / left ventricular ejection fraction (LVEF) is still considered important because prognosis, therapeutic response, as well as most clinical trials, divide patients based on FEVKi. HF is composed of 50% normal $\geq$% LVEF, HF with preserved ejection fraction (HFpEF) $\geq$50%, and HF with reduced ejection fraction (HFrEF) $\leq$ 40%. Patients with LVEF in the range of 40-49% represent a 'gray area' defined as HfmEF (HF) with mid-range ejection fraction) (Aladin et al., 2021). This makes heart failure a serious medical problem. Based on RISKESDAS 2018, the prevalence of heart failure reaches >5% and is found to be the largest population in the age of

55-64 years (3.9%), followed by the population aged 45-54 years (2.4%) and 35-44 years (1.3%). Heart failure is included in 10 non-communicable diseases, with the number of sufferers being 229,696, which is predicted to increase. The mortality rate associated with heart failure was 10% in the Heart Failure preserved Ejection Fraction (HFpEF), 9% in the Heart Failure mildly reduced Ejection Fraction (HFmrEF), and 11% in the Heart Failure reduced Ejection Fraction (HFrEF) population (Álvarez-Bueno et al., 2022; Fresnais et al., 2021; Goh et al., 2022; Goyal et al., 2024; Haley et al., 2007; Hugenschmidt et al., 2020).

Memory is a process of retrieving, storing, and reappearing information that has been recorded for a moment or for a long time and is one of the important cognitive functions in the lives of all creatures on earth. Memory can be impaired with various neuropathologist that affect the neural networks of the memory system in the brain. Patients with heart failure experience a decline in cognitive function globally across multiple domains, including executive function, psychomotor speed, and verbal memory. The prevalence of cognitive impairment in patients with heart failure is about 14.9% (Amelia et al., 2022).

Carotid Intima Media Thickness / CIMT, is an important atherosclerotic risk marker. Several studies have shown that CIMT is a risk factor for cardiovascular disease and a predictor of myocardial infarction, sudden death, and the risk of stroke. Atherosclerosis associated with CIMT and coronary heart disease may increase afterload stress, which causes diastolic dysfunction and systolic dysfunction. Melander et al.'s research found that an increase in CIMT and CRP (C-Reactive Protein) can independently increase the risk of heart failure. Several studies have found that CIMT is one of the signs of cognitive impairment (Angaran et al., 2020; Bourgognon & Cavanagh, 2020; Darabian et al., 2013; Kasliwal et al., 2014; Leto & Feola, n.d.).

Based on this background, where there are still few results on the effect of carotid intima media thickness on memory function in heart failure disease, which is rare in Indonesia, the researcher wants to investigate the effect of carotid intima media thickness on memory function in heart failure patients, with the aim of improving the quality of life of these patients. Although heart failure is a prevalent and critical cardiovascular condition with known associations to cognitive decline, limited research has specifically investigated the relationship between Carotid Intima Media Thickness (CIMT) and memory function in heart failure patients, especially in the Indonesian clinical setting. Previous studies have independently identified CIMT as a marker of atherosclerosis and as a predictor of both cardiovascular and cerebrovascular events. Likewise, cognitive impairment, particularly involving memory, is recognized among individuals with heart failure. However, integrated research that correlates CIMT measurements with specific cognitive domains such as memory function in heart failure populations remains scarce.

This study addresses a significant gap by exploring the direct association between CIMT and memory function in patients with varying subtypes of heart failure (HFpEF, HFmrEF, HFrEF). Furthermore, it contributes novel local data from Indonesia, a country where such investigations are still rare. The research aims not only to enhance clinical understanding of the vascular-cognitive relationship in HF patients but also to inform targeted strategies that could improve their quality of life through early detection and intervention for cognitive decline. This contextual and focused exploration of CIMT's impact on memory in heart failure

patients distinguishes this study from prior research and positions it as a valuable addition to the field of neuroradiology.

Based on the background of the study, this research seeks to investigate two main problems. First, it aims to determine whether there is a significant relationship between memory function and heart failure in patients with reduced left ventricular ejection fraction. Second, it explores whether the thickness of the carotid intima-media has an effect on memory function in the same group of patients. These problems are formulated to better understand the cognitive implications of cardiac dysfunction and vascular changes in individuals with heart failure.

In line with the problem formulation, the objective of this research is to analyze the influence of memory function and carotid intima-media thickness on heart failure patients who experience a decrease in left ventricular ejection fraction. This study is expected to provide valuable insights into the neurological and vascular correlates of heart failure, which may support early detection and holistic management strategies for affected individuals.

The general purpose of this study is to assess the ability to predict memory function in heart failure patients with decreased left ventricular ejection fraction using the Word List test, recall, and recognition at Prof. Dr. R.D. Kandou Hospital. This study aims to examine the relationship between Carotid Intima Media Thickness (CIMT) and various domains of memory function in patients with heart failure who have decreased left ventricular ejection fraction. Specifically, the objectives are to determine the effect of CIMT on immediate memory, recall memory, and recognition memory. By exploring these cognitive aspects, the study seeks to understand how vascular changes reflected by CIMT may contribute to memory impairments commonly observed in individuals with compromised cardiac function.

This study serves as a valuable exercise in developing critical thinking and applying appropriate research methodologies, enabling researchers to gain practical experience in conducting systematic investigations. Furthermore, the research provides deeper insights into the relationship between carotid intima-media thickness and memory function in patients with heart failure and reduced left ventricular ejection fraction. By exploring this correlation, the study contributes to a better understanding of how vascular changes may influence cognitive decline in this specific patient population, offering implications for early diagnosis and targeted intervention. The results of this study can add information and references about improving memory function and can improve the quality of life of heart failure patients with decreased left ventricular ejection fraction. The results of this study are expected to provide preliminary data for further research on the effect of carotid intima media thickness on memory function or on other cognitive functions in heart failure patients with decreased left ventricular ejection fraction.

This study employed an observational hospital-based research design with a cross-sectional data collection approach. Data collection was conducted through simultaneous examinations of memory function and Carotid Intima Media Thickness (CIMT). The research took place at the neurological memory polyclinic of Prof. Dr. R. D. Kandou Manado Hospital and continued until the required number of samples was achieved. The study commenced following approval from the ethics committee of the same hospital.

The target population in this research comprised patients with heart failure who visited or were hospitalized in the Heart and Vascular Diseases Section of Prof. Dr. R. D. Kandou Manado Hospital during the data collection period. More specifically, the accessible population included Indonesian adult patients diagnosed with heart failure characterized by reduced left ventricular ejection fraction who received outpatient or inpatient care at the aforementioned hospital department.

Participants were selected using a purposive sampling technique. Patients who met the inclusion criteria and agreed to participate were included in the study until the sample size requirement was fulfilled. The inclusion criteria consisted of the following: patients aged between 45 and 70 years who had been diagnosed with heart failure and met the diagnostic criteria for reduced ejection fraction (NYHA functional class ≤ III); the ability to respond to interview questions; no history of head trauma, cerebrovascular disease, or organic mental disorders; not using pacemakers or cardiac resynchronization devices; maintaining sinus rhythm; and providing consent to undergo cardiac record examinations, echocardiography, carotid Doppler ultrasound, and memory function tests.

Exclusion criteria included patients experiencing an acute phase of heart failure, those with severe acute respiratory failure, those who had ventricular or supraventricular arrhythmias or atrial fibrillation, and those who were uncooperative during the examination.

The required sample size was calculated using Lem show's formula, with a prevalence (P) value of 2.7% based on literature. The formula used was:

$$n = Z^2 \times P \times Q / d^2,$$

Where:
Q = 1 – P (0.973)
d = 0.05
Z = 1.96, resulting in a required minimum sample size of 40 participants.

The main research variables in this study were the measurement of Carotid Intima Media Thickness (CIMT) and the assessment of memory function, which was quantified using numerical scales.

Tabel 1. Operational Variables and Definitions

Variable	Operational Definition	Scale
Variable bound		
Memory Function	Memory is a process of retrieving, storing and reappearing information that has been recorded for a moment or for a long time which is assessed by the Word List Memory Test, consisting of Immediate memory, Recall memory and recognition memory	Numerical
Major independent variables		
CIMT	The results of the combined thickness measurement of the media tunica and the adventitious tunica of the carotid artery wall are expressed in mm units.	Numerical
Other independent variables that have the potential to be confusing		
Age	The age of the patient at the time of the visit, in years.	Numerical

Variable	Operational Definition	Scale
Gender	The gender of the patient is differentiated between male and female.	Category
Hypertension	The existence of a history of hypertension in individuals can be confirmed through an anamnesis and clinical examination with systolic blood pressure > 140 mmHg and/or diastolic blood pressure > 90 mmHg	Numerical
Urea	Blood Urea Levels. Expressed in mg/dL.	Numerical
Creatinine	Blood creatinine levels. Expressed in g/dL.	Numerical
GMOs	The presence of a history or condition of mental disorders caused by impaired brain function, such as a condition of decreased consciousness + amnesia, and dementia. Confirmed through anamnesis. Expressed with yes and no	Numerical

Source: by Researcher

RESEARCH METHOD

How it Works and Equipment

How It Works

This research will be carried out on subjects who meet the established inclusion criteria. The process begins with collecting the subject's personal data, including name, age, gender, educational background, residential address, patient registration number, and duration of symptoms. Once the subject is confirmed to have heart failure with reduced left ventricular ejection fraction—diagnosed through echocardiographic examination—the next step involves conducting a Carotid Intima-Media Thickness (CIMT) examination. Afterward, the researcher provides a thorough explanation regarding the memory function test that will be administered to the participant. All collected data will then be organized and tabulated, and the results will be presented in graphical form for ease of interpretation and analysis.

Equipment

The tools used in this study include a *Word List* test question sheet, which serves to assess memory function through a validated list of words in the Indonesian language. This list consists of 10 words *butter*, *hands*, *beach*, *letter*, *queen*, *room*, *pool*, *ticket*, *grass*, and *machine*. The memory test is conducted in three stages. In the first stage, participants are asked to immediately repeat as many of the 10 words as they can recall right after the examiner speaks them. This is referred to as the *immediate recall* test, with a maximum score of 10. In the second stage, a *delayed recall* test is conducted 5 to 10 minutes later, where participants are again asked to recall as many of the original 10 words as possible, with the same scoring range. In the third stage, a *recognition* test is performed in which the participant identifies the original 10 words from a larger list of 20 words read aloud by the examiner; the maximum score remains 10.

In addition to the *Word List* test, a *Word List Recall* and *Recognition* sheet is also used, where participants are instructed to rename the memorized words. They are then presented with a series of words and must indicate "yes" if the word has been previously seen or memorized, and "no" otherwise. Supporting tools include a research form for recording responses and writing stationery for documentation purposes.

Data Processing and Analysis

The collected data are first recorded manually on the research form, after which they undergo a cleaning process to ensure completeness and consistency. Subsequently, the data are coded and tabulated before being entered into a computer system for analysis using SPSS software. The first stage of data analysis involves a univariate analysis to describe the characteristics of each variable. This is followed by a normality test using the Kolmogorov-Smirnov test to assess whether the numerical data follow a normal distribution. To test the research hypothesis, a Pearson regression analysis is conducted, applying a simple linear regression model to explore the relationship between the independent and dependent variables. The final results are then presented in both narrative and tabular formats to ensure clarity and facilitate interpretation.

Research Ethics Review

This research will be carried out after obtaining permission from the Ethics Test Committee of Prof. Dr. R. D. Kandou Hospital, Manado.
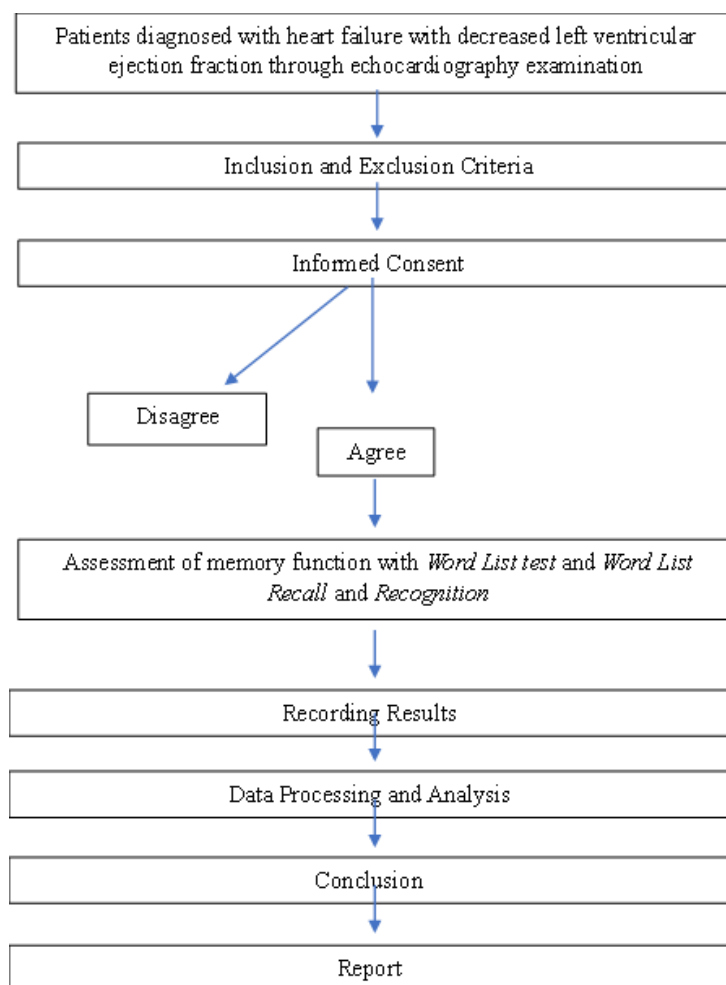
Research Flow

Figure 1. Research Flow

Research Schedule

Table 2. Research schedule

Yes	Types of Activities	Month/Year							
		June 2024	Jul 2024	Aug 2024	Sep 2024	Oct 2024	Nov 2024	From 2024	Jan 2024
1	Proposal creation	▓	▓						
2	Ethical management of research	▓	▓						
3	Creation of research forms	▓	▓						
4	Procurement of research equipment	▓	▓						
5	Research team meeting	▓	▓						
6	Sampling		▓	▓	▓	▓			
7	Creation of research progress reports				▓	▓	▓		
8	Data analysis					▓	▓	▓	
9	Creation of the final research report						▓	▓	
10	Publication							▓	▓

RESULTS AND DISCUSSION

Demographic Characteristics of Research Subjects

The purpose of this study is to determine the effect of *carotid intima media* thickness on memory function in heart failure patients with decreased left ventricular ejection at Prof. R.D Kandou Hospital. This study involved 52 heart failure patients with decreased left ventricular ejection fraction according to inclusion and exclusion criteria. This study is a hospital-based observational analytical study with prospective data collection on patients who receive both inpatient and outpatient care in the Heart and Vascular Section of the Prof. R.D. Kandou Manado Central Hospital. Most of the subjects of this study were 58 years old (46-65), male (81%).

Table 3. Characteristics of Research Objects

VARIABLE	n (%)	n (%)	Median (IQR)
Age, yrs	-	56,8 (5,5)	58 (46 – 65)
Gender			
Man	42 (81)	-	-
Woman	10 (19)	-	-

Source: by Researcher

Clinical Characteristics of Research

This carotid intime media thickness consists of 6 components, namely CCA dextra, CCA sinistra, bulb dextra, bulb sinistra, ICA dextra and ICA sinistra and memory function consists of which is tested by *Word List Test* of 3 components, namely *immediate, recall* and *recognition.*

Table 5. Clinical Characteristics of Research

CIMT, cm	
CCA Dextra	0,75 (0,26)
CCA Sinistra	0,75 (0,23)
BULB Dextra	0,88 (0,35)
BULB Sinistra	0,80 (0,27)
ICA Dextra	0,63 (0,22)
ICA Sinistra	0,60 (0,19)
Word List Test	
Immediate	0,75 (0,26)
Recall	0,62 (0,15)
Recognition	0,74 (0,17)

Impact Analysis Results *Carotid Intima Media Thickness* **on Memory Function** *Immediate Memory Test* **Heart Failure patients with decreased left ventricular ejection fraction**

Testing the ability *of Carotid Intima Media Thickness* to affect immediate *memory function of heart* failure patients with decreased left ventricular ejection fraction was analyzed by regression analysis and Pearson correlation. *Carotid Intima Media Thickness* as an independent variable and *immediate memory test* (from *the Word list memory test examination)* as a dependent variable. The independent *variable of Carotid intima media thickness* consists of 6 components, namely CCA Dextra, CCA Sinistra, Bulbus Dextra, Bulbus Sinistra, ICA Dextra and ICA Sinistra.

The results of the analysis can be seen in Table 4.3 where there is 1 component of Carotid Intima Media *Thickness* , namely CCA Sinistra which has a significant effect on memory function – *immediate memory test* in heart failure patients with a reduced left ventricular ejection fraction because it has a P value of < 0.05, while other components of Carotid Intima Media *Thickness* have an effect but not significantly on memory function *immediate* heart failure patients with decreased left ventricular ejection fraction because they have a P value of > 0.05.

Table 6. Analysis of the effect of CIMT on memory function – *immediate memory test* **of heart failure patients with decreased left ventricular ejection fraction**

CIMT Components	Value r	R2 Value	Value p
CCA Dextra	0,132	0,017	0,350
CCA Sinistra	0,390	0,152	0,004
Bulb Dextra	0,089	0,008	0,532
Bulb Sinistra	0,016	0,000	0,910
ICA Dextra	0,055	0,003	0,698
ICA Sinistra	0,127	0,016	0,369

Note: the P value is said to be significant when < 0.05
Source: by Researcher

Impact Analysis Results *Carotid Intima Media Thickness* **against Memory Function -** *Recall memory test* **Heart Failure patients with decreased left ventricular ejection fraction**

Testing of the ability of Carotid Intima Media Thickness affects memory function – *recall memory test* of heart failure patients with decreased left ventricular ejection fraction was analyzed by regression analysis and Pearson correlation. *Carotid Intima Media Thickness* as an independent variable and memory recall *function* as a dependent variable. The *carotid intima media thickness-free* variable consists of 6 components, namely CCA Dextra, CCA Sinistra, Bulbus Dextra, Bulbus Sinistra, ICA Dextra and ICA Sinistra.

The results of the analysis can be seen in Table 4.4 where there are 2 components of Carotid Intima Media *Thickness*, namely CCA Dextra and CCA Sinistra which have a significant effect on memory function - *recall memory test* of heart failure patients with a reduced left ventricular ejection fraction because it has a P value of < 0.05, while the *component of carotid intima media thickness* others had an effect but not significantly on memory recall function in heart failure patients with a decreased left ventricular ejection fraction because they had a P value of > 0.05.

Table 7. Analysis of the effect of CIMT on memory function *recall memory test* **of heart failure patients with decreased left ventricular ejection fraction**

CIMT Components	Value r	R2 Value	Value p
CCA Dextra	0,388	0,151	0,004
CCA Sinistra	0,291	0,085	0,036
Bulb Dextra	0,092	0,009	0,514
Bulb Sinistra	0,066	0,004	0,644
ICA Dextra	0,030	0,001	0,834
ICA Sinistra	0,253	0,064	0,070

Note: the P value is said to be significant when < 0.05
Source: by Researcher

Impact Analysis Results *Carotid Intima Media Thickness* **on Memory Function –** *Recognition Memory Test* **Heart Failure patients with decreased left ventricular ejection fraction**

Testing of *the ability of Carotid Intima Media Thickness* affects memory function - *recognition memory test* of heart failure patients with decreased left ventricular ejection fraction was analyzed by regression analysis and Pearson correlation. Carotid *Intima Media Thickness* as an independent variable and memory function - *recognition memory test* as a dependent variable. The free variable of C*arotid Intima Media Thickness* consists of CCA Dextra, CCA Sinistra, Bulbus Dextra, Bulbus Sinistra, ICA Dextra and ICA Sinistra.

The results of the analysis can be seen in Table 4.5 where there is 1 component of Carotid Intima Media *Thickness*, namely CCA Sinistra which has a significant effect on memory function - *recognition memory test* of heart failure patients with a reduced left ventricular ejection fraction because it has a P value of < 0.05, while other components *of Carotid Intima Media Thickness* do not have a significant effect on memory function - *Recognition memory test* of heart failure patients with a decreased left ventricular ejection fraction because they had a P value of > 0.05.

Table 8. Analysis of the Influence of CIMT on Memory Function – *Recognition Memory Test* of Heart Failure Patients with Decreased Left Ventricular Ejection Fraction

CIMT Components	Value r	R2 Value	Value p
CCA Dextra	0.182	0.033	0.197
CCA Sinistra	0.447	0.200	0.001
Bulb Dextra	0.057	0.003	0.686
Bulb Sinistra	0.099	0.010	0.486
ICA Dextra	0.026	0.001	0.852
ICA Sinistra	0.128	0.016	0.367

Note: the P value is said to be significant when < 0.05
Source: by Researcher

Analysis of the influence of all components *Carotid Intima Media Thickness* together with the Memory Function *Immediate Memory Test* Heart Failure patients with decreased left ventricular ejection fraction

Multivariate influence testing of all *components of Carotid Intima Media Thickness* with memory function - *immediate memory test* using *multiple linear regression* analysis using *the stepwise* method. This analysis is used because all Carotid Intima Media Thickness data are numerical as an independent variable, and memory function data - *immediate memory test* is also numerical as a dependent variable. The *carotid intima media thickness-free* variable consists of 6 components, namely CCA Dextra, CCA Sinistra, Bulbus Dextra, Bulbus Sinistra, ICA Dextra and ICA Sinistra.

The results of the analysis in table 4.6 can be concluded that there is only one component *of the carotid intima media thickness* that has a significant effect on immediate memory function , namely CCA Sinistra because it has a p value of 0.004 ($p < 0.05$) but has a negative regression coefficient, so it can be concluded that the higher the CCA Sinistra, the lower the immediate memory function.

Table 9. Multivariate Test Results of All Components *of Carotid Intima Media Thickness* with Immediate Memory Function of Heart Failure Patients with Decreased Left Ventricular Ejection Fraction

CIMT Components	Regression Coefficients	Value p
Constant	21,468	
CCA Sinistra	-7,642	0,004

Note: the P value is said to be significant when < 0.05
Source: by Researcher

Analysis of the Influence of all Components *Carotid Intima Media Thickness* Together with the Memory Function *Recall Memory test* Heart Failure Patients with Decreased left Ventricular Ejection Fraction

Multivariate influence testing of all components of *Carotid Intima Media Thickness* with memory recall function using multiple *linear regression* analysis using *stepwise* method. This analysis is used because all *Carotid Intima Media Thickness* data is numerical as an independent variable, and the *memory* function data is also numerical as a dependent variable.

The *carotid intima media thickness-free* variable consists of 6 components, namely CCA Dextra, CCA Sinistra, Bulbus Dextra, Bulbus Sinistra, ICA Dextra and ICA Sinistra.

The results of the analysis presented in table 4.7 can be concluded that there are two components *of carotid intima media thickness* that have a significant effect on memory *recall* function because they have a p value of < 0.05, namely CCA Dextra and CCA Sinistra. CCA Dextra and CCA Sinistra each have a negative regression coefficient, so it can be concluded that the higher the CCA Dextra and CCA Sinistra, the lower the memory function will be.

Table 10. Multivariate Test Results of All Components *of Carotid Intima Media Thickness* with Memory Recall Function of *Heart* Failure Patients with Decreased Left Ventricular Ejection Fraction

CIMT Components	Regression Coefficients	Value p
Constant	4,305	
CCA Dextra	-109,022	0,042
CCA Sinistra	-115,202	0,032

Note: the P value is said to be significant when < 0.05
Source: by Researcher

Analysis of the influence of all components *Carotid Intima Media Thickness* together with the Memory Function *Recognition* Heart Failure patients with decreased left ventricular ejection fraction

Multivariate influence testing of all components of *Carotid Intima Media Thickness* with memory *recognition* function using multiple *linear regression* analysis using *the stepwise* method. This analysis is used because all *Carotid Intima Media Thickness data* are numerical as independent variables, and memory recognition function data are also numerical as dependent variables. The *carotid intima media thickness-free* variable consists of 6 components, namely CCA Dextra, CCA Sinistra, Bulbus Dextra, Bulbus Sinistra, ICA Dextra and ICA Sinistra.

The results of the analysis of table 4.8 can be concluded that there is only one component of *carotid intima media thickness* that has a significant effect on memory *recognition function*, namely CCA Sinistra because it has a p value of 0.001 (p < 0.05) but has a negative regression coefficient, so it can be concluded that the higher the CCA Sinistra, the lower the memory *recognition* function.

Table 11. Multivariate Test Results of All Components *of Carotid Intima Media Thickness* with Memory *Recognition Function of* Heart Failure Patients With Decreased Left Ventricular Ejection Fraction

CIMT Components	Regression Coefficients	Value p
Constant	11,027	
CCA Sinistra	-3,801	0,001

Note: the P value is said to be significant when < 0.05
Source: by Researcher

Discussion

Basic Characteristics of Research Subjects

The study subjects who participated in this study amounted to 52 heart failure patients with decreased left ventricular ejection fraction with the majority of the sample being male (81%). The age range for those who participated in this study was between 46-65 years. This is similar to the findings *Framingharm Heart Study*, *Rotterdam Study* and research conducted by Gao et al. that the incidence of heart disease is more common in men than women. Research *Southern European community-based Epidemiology of Heart Failure and Learning (EPICA) study* , *Atherosclerosis Risk in Communities* (ARIC) and research by Carolyn et al. found that the risk of heart failure with a lower left ventricular ejection fraction in men compared to women was associated with a predisposition to macrovascular coronary artery disease and myocardial infarction. Pooja et al's research found that treatment in men with HFrEF had a better quality of life than women, because women received less than optimal treatment. The hormones progesterone and estrogen are still produced in middle age, where these hormones can protect against various diseases such as heart disease due to atherosclerosis, so in this study a sample with a middle age range.

The average values obtained from this study were 0.75 (0.26) cm, 0.75 (0.23) cm, 0.88 (0.35) cm, 0.80 (0.27) cm, 0.63 (0.22) cm, 0.60 (0.19) cm and 0.74 (0.17) cm for CCA dextra, CCA sinistra, Bulbus dextra, Bulbus sinistra, ICA dextra, ICA sinistra and the average CIMT respectively. This is different from research from *Multi-Ethnic study of Atherosclerosis* (MESA) in the USA obtained an average CIMT value in the heart failure population with a decreased left ventricular ejection fraction of 1.3 ± 0.71 cm and 0.95 ± 0.21 cm for the average ICA and CCA. The MESA study said that the increase in CIMT was associated with the incidence of heart failure both in the left ventricular ejection fraction decreased and in the preserved ventricular ejection fraction. In several studies, increased CIMT was associated with increased systemic inflammatory markers such as C-reactive protein, decreased myocardial flow in populations with and without CHD, and diastolic and systolic functions associated with heart failure incidence were predictors of heart failure incidence.

Influence *Carotid Intima Media Thickness* to Memory Function, *Immediate Memory* in Heart Failure Patients with Decreased Left Ventricular Ejection Fraction

The analysis of this study found that *Carotid Intima Media Thickness Components* that affect the *Immediate memory, Recall* and *Recognition memory* be *Common Carotid Artery* sinistra. This is likely due to the anatomy of the vessels from the heart to the brain. The carotid artery supplies circulation to the anterior region of the brain. In most patients, the right communist carotid artery arises from the brachiocephalic artery while the left communist carotid artery arises directly from the aorta. The communist critical artery supplies blood to the internal carotid artery and the external carotid artery. *Carotid Intima Media Thickness* is a measure of the distance between the lumen of the intima to the media-adventia on the wall of the carotid artery. *Carotid intima media thickness* And the thickness of the internal carotid artery is a predictor that describes a form of atherosclerosis. Carotid atherosclerosis, defined as thickening of BMI, can be a sign for the early stages of memory impairment, especially for *immediate memory*. This damage is thought to be caused by cerebral microvascular disorders

that affect the frontal lobe. As is known, the frontal lobe is innervated by an internal carotid artery which originates from the communist carotid artery. This is in accordance with the research conducted by Matsumoto et al conducted in Japan that subclinical carotid atherosclerosis measured by CIMT is an early sign of cognitive impairment, especially in *immediate memory recall*. *Immediate memory* It can be a useful marker for detecting early changes in cerebral function associated with subclinical atherosclerosis and be a predictive sign for cognitive impairment of vascular origin.

Patients with decreased left ventricular ejection fraction have cerebral hypoperfusion due to decreased blood flow to the brain which can lead to significant memory deficits. *Recall* and *Memory recognition* Included in declarative memory or implicit memory is the radius of this declarative memory through the parahippocampus-hippocampus cortex and back to the brain for storage known as long-term memory. *Recall memory* tend to be more affected compared to *Memory recognition* due to the *Recall* requires more complex cognitive activity and involves more brain areas such as the hippocampus and prefrontal cortex. The hippocampus, as the main center of memory, is very sensitive to the lack of oxygen and nutrients caused by hypoperfusion. The hippocampus relies heavily on the vascularization provided by the branches of the internal carotid artery originating in the communist carotid artery. This association shows the presence of the communist carotid artery in the function of the hippocampus with an adequate blood supply. The results of this study are in accordance with a retrospective study conducted by Joanne et al in New York, USA on 207 heart failure patients with reduced left ventricular ejection fraction with memory function. The results of their study found that patients with decreased left ventricular ejection fraction experienced a decrease in memory, especially in ability to *Recall* and *Memory recognition.*

Advantages and Disadvantages of Research

This study is the first study to assess the effect of *Carotid Intima Media Thickness* on memory function in heart failure patients with a decreased left ventricular ejection fraction in the neurology department of Prof. R.D. Kandou Manado Hospital. Given the high prevalence of heart disease in North Sulawesi, a more in-depth examination is needed for memory function that is useful in preventing deterioration in memory function in heart failure patients. The weakness of this study is that it uses samples from one hospital, namely at Prof. R.D Kandou Hospital and memory function checks are carried out by several examiners.

CONCLUSION

The results of the analysis of the influence of *CIMT* on memory function *immediate memory* found that *CCA Sinistra* had a significant effect. The results of the analysis of the influence of *CIMT* on memory function *recall memory* found that *CCA Dextra* and *Sinistra* had a significant effect. The results of the analysis of the influence of *CIMT* on memory function *recognition memory* found that *CCA Sinistra* had a significant effect. The results of the multivariate test of all *CIMT* components with memory function *immediate memory* were obtained by *CCA Sinistra*, which had a significant effect on heart failure patients with decreased left ventricular ejection fraction. The results of the multivariate test of all *CIMT* components with memory function *recall memory* obtained *CCA Dextra* and *Sinistra*, which had a

significant effect on heart failure patients with decreased left ventricular ejection fraction. The results of the multivariate test of all *CIMT* components with memory function—*recognition memory* were obtained by *CCA Sinistra*, which had a significant effect on heart failure patients with decreased left ventricular ejection fraction

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