Study of cerebral circulation hemodynamics in prevalent hemodialysis patients

Thesis

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Presented by

Mahmoud Sadek AL-Semrawy

M.B. B.Ch.

Supervised by

Prof. Dr. *AbdEL-baset AL Shaarawy Abd EL-Azeem*

Professor of Internal Medicine and Nephrology

Faculty of Medicine, Ain Shams University

Dr. *Maha Abd EL-Moneim Behairy*

Lecturer of Internal Medicine and Nephrology

Faculty of Medicine, Ain Shams University

Dr. *Ahmed Mohammed EL-Sadek*

Lecturer of Neurology

Faculty of Medicine, Ain Shams University

Faculty of Medicine

Ain Shams University

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مقدمة من

□ محمود صادق السمراوي/الطبيب

بكالوريوس الطب و الجراحة

تحت إشراف

□أد/ عبدالباسط الشعراوي عبدالعظيم

أستاذ امراض الباطنة والكلي

كلية الطب- جامعة عين شمس

د/ مها عبدالمنعم بحيري

مدرس امراض الباطنة والكلي

كلية الطب- جامعة عين شمس

□د/ أحمـــد محمد الصادق

مدرس طب المخ والأعصاب

كلية الطب- جامعة عين شمس

كلية الطب

جامعة عين شمس

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Mahmoud Sadek Mahmoud Al Semrawy .

Contents

List of Abbreviations

ACA	:	Anterior cerebral artery
ACZ	:	Acetazolamide
ADMA	:	Asymmetric dimethyl arginine.
ALT	:	Alanine transaminase
AST	:	Aspartate transaminase
BA	:	Basilar artery
BP	:	Blood pressure
BUN	:	Blood urea nitrogen
BOLD	:	Blood oxygen level dependent
CA	:	Cerebral autoregulation
CAD	:	Coronary artery disease
CBF	:	Cerebral blood flow
CBS	:	Cystathionine B synthase
CBV	:	Cerebral blood volume
CI	:	Cognitive impairment
CKD	:	Chronic kidney disease
CPP	:	Cerebral perfusion pressure
CRP	:	C-reactive protein
CT	:	Computed tomography
CVD	:	Cardiovascular disease
CVR	:	Cerebral vasomotor reactivity
eGFR	:	Estimated glomerular filtration rate
ESRD	:	End stage renal disease
FBS	:	Fasting blood sugar
FMRI	:	Functional magnetic resonance imaging
FV	:	Flow velocity
GM	:	Gray matter
Hb	:	Hemoglobin
HCY	:	Homocysteine
HD	:	Hemodialysis
HDL	:	High density lipoprotein
HGF	:	Hepatocyte growth factor
ICA	:	Internal carotid artery
ICH	:	Intra cerebral hemorrhage
ICP	:	Intra cranial pressure
in	:	Inch
INR	:	International normalized ratio
iPTH	:	Intact parathyroid hormone

K	:	Potassium
kg/m^2	:	Kilogram/meter square
LDL	:	Low density lipoprotein
LP	:	Lipoprotein
LVD	:	Left ventricular dysfunction
LVH	:	Left ventricular hypertrophy
MAP	:	Mean arterial pressure
MCA	:	Middle cerebral artery
MFV	:	Mean flow velocity
Mg	:	Magnesium
MRI	:	Magnetic resonance imaging
Na	:	Sodium
NIRS	:	Near infrared spectroscopy
NO	:	Nitric oxide
OA	:	Ophthalmic artery
OEF	:	Oxygen extraction fraction
PCA	:	Posterior cerebral artery
PET	:	Positron emission tomography
pg	:	Picogram/milliliter
PI	:	Pulsatility index
Po_4	:	Phosphate
PTH	:	Parathyroid hormone
SAH	:	Subarachinoid hemorrhage
SCI	:	Silent cerebral infarction
SD	:	Standard deviation
SPECT	:	Single photo emission computed tomography
TCCD	:	Transcranial color coded duplex
TCD	:	Transcranial Doppler
TIA	:	Transient ischemic attack
TICA	:	Terminal portion of the internal carotid artery
URR	:	Urea reduction ratio
VR	:	Vertebral artery
WMH	:	White matter hyperintensities

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Abstract

In the current study, fifty prevalent HD patients were included from El Sahel teaching hospital dialysis units. All patients were on regular HD thrice weekly for at least 6 month, each dialysis session lasted four hours with clinically stable condition. In our study we exclude patients with cerebrovascular insult, active collagen disease, diabetes mellitus, uncontrolled hypertension, severe anemia ≤ 8 g/dl, decompensated chronic liver disease , heavy smokers and active inflammation. All patients were subjected to clinical examination; Fasting serum samples were obtained. All biochemical blood samples were collected before the mid-week HD session and before heparin administration. Laboratory investigations included: Hemoglobin level, urea (pre& post dialysis), creatinine, Urea reduction ratio (URR), albumin, calcium, phosphorus, PTH, CRP titer, lipid profile, and HCV Ab were done. An informed detailed consent was taken from the patients before the start of the study.

Cerebral circulation was assessed by measuring mean flow velocity in middle cerebral artery and posterior cerebral artery in non-dialysis day using trans cranial Doppler sonography machine.

This study included 18 (32%) female patients and 27 (68%) male patients with mean of age 43.4 years and range from 22-62 years. The mean of HD duration was 71.36 months.

Key word:

Blood oxygen level dependent, C-reactive protein, Fasting blood sugar, Intra cerebral hemorrhage, Magnesium , Parathyroid hormone.

Introduction

Hemodialysis is the most common treatment for ESRD. Transient hypotension, arterial hypoxemia ,and fluctuations in electrolytes and cerebral water content might occur during hemodialysis and possibly induce subtle brain damage. It is unestablished whether dialysis treatment improves or exacerbates the cognitive deficits of ESRD or the underlying cardiovascular disease ***(Monk and Bennett, 2006).*** Previous literature suggests the possibility of deleterious hemodialysis effects on cognition ***(Gilli and De Bastiani, 1983).***

Patients with End-stage renal disease (ESRD) are at increased risk of cerebrovascular diseases with a risk approximately 5-10 times higher than the general population. Signs of cerebrovascular disease are common and suggestive of vascular related injury ***(Sozio et al,2009).***

ESRD has been associated with accelerated vascular disease and premature atherosclerosis of the cerebral circulation due to uremic toxins and augmentation of traditional risk factors of atherosclerosis ***(Mehdi et al, 2012***).

The risk of stroke as a frequent complication of uremia, which can result from acute cerebral blood flow reduction, is five times higher in dialysis patients than the general population. Decreasing of brain tissue perfusion has deleterious nature in uremic patients, as it increases the incidence of cerebral atrophy, especially in combination with a low hematocrit and the presence of accelerated and premature atherosclerosis along with traditional risk factors (***Seligeret al,2003).***

The process of conventional hemodialysis may induce recurrent episodes of acute cerebral ischemia, which in turn may contribute to acute decline in cognitive functions during dialysis. Thus the worst time to communicate with dialysis patients may be during the hemodialysis sessions (***Murray et al, 2006).***

In the normal brain, the constancy of cerebral blood flow and volume relies on the intrinsic ability of the cerebral arteries to alter their caliber in response to variations in blood pressure (auto regulation). Changes in regional metabolic demands with ESRD patients, cerebral vessels undergo structural changes, with subsequent impairment in the hemodynamic auto regulation processes, making stroke frequent complication in uremic patients on dialysis(***KuwabaraY et al,2002).***

Aim of the work

To evaluate cerebral circulation hemodynamics in prevalent hemodialysis patients by trans cranial Doppler sonography.

Cerebral circulation disorders in chronic kidney disease

Normal Cerebral Blood Flow (CBF):

The human brain represents approximately 2% of total body weight, yet it receives approximately 20% of cardiac output and uses 20% of total body oxygen consumed under normal conditions. In this situation, most of the energy of the brain is obtained exclusively from aerobic metabolic process. The impairment in the supply of nutrients and oxygen to the brain can cause cellular damage ***(Bor-seng et al, 2012).***

Regulation of cerebral blood flow:

Regulation of blood flow in the human brain is exceedingly complex. There are three main regulatory parameters involved in the regulation of cerebral blood flow: cerebral auto regulation, flow-metabolism coupling, and neurogenic regulation. In addition, there are two cell types that have repeatedly been shown to play a central role in the regulation of cerebral blood flow: endothelial cells and astrocytes ***(Peterson et al, 2011).***

1. Cerebral auto regulation:

Cerebral Auto regulation (CA) is the intrinsic ability of the brain to maintain stable cerebral blood flow (CBF) while mean arterial blood pressure (MAP) and cerebral

perfusion pressure (CPP) are changing. It constitutes a regulatory mechanism to provide metabolic substrates under physiological and pathological conditions. Constant CBF is regulated by changing arteriolar diameter, which will alter cerebral blood volume (CBV) and ultimately, intra-cranial pressure (ICP) ***(Bor-seng et al, 2012).***

Cerebral Auto regulation (CA) has two components;

(a) **Metabolic Auto regulation**; which is the cerebrovascular response to changes in brain tissue PH. Vasodilatation occurs when tissue PH drops during ischemia, hypoxia or hypercapnic events, in contrast respiratory alkalosis results in cerebral vasoconstriction. Metabolic auto regulation can be measured via the CBF response to change in paCO2 ***(Lang et al, 2005).***

(b) **Pressure Auto regulation**, which is the cerebrovascular response to changes in trans mural vascular pressure resulting from changes in CPP or MAP. Moreover, Pressure auto regulation has a slow component, referred to as "static CA" and a fast component, namely "dynamic CA". In normal situation, where pressure auto regulation is intact, CBF is kept constant over the range of arterial pressure from 50-150mmHg. Below and above the ABP range, pressure auto regulation is no longer maintained and CBF approximates to a linear relationship with CPP (Figure 1, 2) ***(Lang et al, 2005).***