Cardiac Surgery and Acute Kidney Injury

An essay
Submitted for the Partial Fulfillment of Master Degree
In Anesthesia

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2010

جراحات القلب و الاصابات الحادة للكلى

رسالـــــــــــة

للحصول على درجة الماجستير في **التخـــــدير**

مقدمة من

الطبيب/ احمد بدر متولى
بكالوريوس الطب و الجراحة

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Summary

Acute kidney injury (AKI), previously known as acute renal failure, after cardiac surgery is one of the most serious complications during the postoperative period. Although the incidence of post-operative AKI is relatively low, it is associated with high mortality rates, usually exceeding 50%.

This study discusses the pathophsiology of acute kidney injury in cardiac surgery and its classification into volume responsive AKI and non-volume responsive AKI. Also it gives an idea about the risk factors for its occurrence and its classification into pre-operative, intra-operative and post-operative factors.

Renal biomarkers like urinary Interleukin-18 and Cystatin C are now considered the future in the early detection and diagnosis of AKI rather than the traditional methods which will help in decreasing the post-operative morbidity and mortality.

Renal protection remains our best weapon to prevent the enormous impact on resources, morbidity and mortality caused by ARF. Once AKI is suspected, the potential strategies for renal protection should be started including non-pharmacological and pharmacological strategies.

Renal replacement therapy is considered the last choice for the management of AKI after cardiac surgeries. Several techniques are today available. Techniques may differ in terms of vascular access, extracorporeal circuit design, infusion sites of replacement fluid, anticoagulation, intensity of treatment, and type of membrane.

List of Abbreviations

ADQI	:	Acute Dialysis Quality Initiative
AKI	:	Acute kidney injury
AKIN	:	Acute Kidney Injury Network
All	:	Angiotensin ll
ANP	:	Atrial natriuretic peptide
AP	:	Alkaline phosphatase
ARB	:	Angiotensin receptor blocker
ARF	:	Acute renal failure
ATN	:	Acute tubular necrosis
BB	:	Brush border
BUN	:	Blood urea nitrogen
CAVH	:	Continuous arteriovenous hemofiltration
CAVHD	:	Continuous arteriovenous hemodialysis
CAVHDF	:	Continuous arteriovenous hemodialfiltration
CHF	:	Congestive heart failure
CMV	:	Cytomegalovirus
CO	:	Carbon monoxide
CO-RMs	:	Carbon monoxide-releasing molecules
CPB	:	Cardiopulmonary bypass
CRF	:	Chronic renal failure
CRRT	:	Continuous renal replacement therapy
CSA-AKI	:	Cardiac surgery associated AKI
CVVH	:	Continuous venovenous hemofiltration
CVVHD	:	Continuous venovenous hemodialysis
CVVHDF	:	Continuous venovenous hemodialfiltration
DCT	:	Distal Convoluted Tubule
DPP	:	Dipeptidyl peptidase
EPO	:	Erythropoietin
EPO-R	:	Erythropoietin receptor
ESRF	:	End stage renal failure
EVAR	:	Endovascular aneurysm repair

List of Abbreviations (Cont.)

FA	:	Folic acid
GFR	:	Glomerular filtration rate
GGT	:	Gamma glutamyl transferase
GGT	:	G Glutamyl transpeptidase
GST	:	Glutathione S transferase
HCT	:	Hematocrit
HO	:	Heme oxygenase
I/D	:	Insertion/deletion
IABP	:	Intraaortic balloon pump
IL-6	:	Interleukin-6
I-R	:	Ischemic reperfuision
IRRT	:	Intermittent renal replacement therapy
JGA	:	Juxtaglomerular Apparatus
KIM 1	:	Kidney injury molecule 1
LAP	:	Leucine aminopeptidase
LDH	:	Lactate dehydrogenase
L-FABP	:	Liver fatty acid binding protein
MAP	:	Mean arterial pressure
MI	:	Myocardial infarction
mTAL	:	Medullary Thick Ascending Loop of Henle
N-AC	:	N- Acetyl cysteine
NAG	:	N acetyl glucosaminidase
NGAL	:	Neutrophil Gelatinase-associated lipocalin
NO	:	Nitric oxide
OPCABG	:	Off-pump coronary artery bypass graft
PCI	:	Percutaneous coronary intervention
PCT	:	Proximal Convoluted Tubule
PGE2	:	Prostaglandin E2
PGs	:	Prostaglandins
PMN	:	Polymorphonucleocytes
PTC	:	Proximal tubular cell

List of Abbreviations (Cont.)

IL-18	:	Urine interleukin 18
P_tO_2	:	Tissue partial pressure of oxygen
RAAS	:	Renin-angiotensin-aldosterone system
RBF	:	Renal blood flow
RCTs	:	Randomized controlled trials
rHuEPO	:	Recombinant human Erythropoietin
RIFLE	:	Risk, injury, failure, loss and end-stage kidney disease
ROS	:	Reactive oxygen species
RRT	:	Renal replacement therapy
S1P1	:	Sphingosine-1-phosphate type 1
SIRS	:	Systemic inflammatory response syndrome
SNS	:	Sympathetic nervous system
TGF	:	Tubuloglomerular feedback
TNF	:	Tumor necrotic factor
VAD	:	Ventricular assist device
V-V circuit	:	Venovenous circuit

List of Tables

List of Figures

List of Contents

Acknowledgement

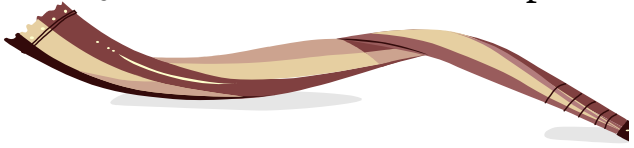
First of all, all gratitude is due to ***allah*** *for blessing this work, until it has reached its end, as a part of his generous help, throughout my life.*

Really I can hardly find the words to express my gratitude to ***Prof. Dr. Gamal Fouad Saleh*** *Professor of anesthesia and intensive care, faculty of medicine, Ain Shams University, for his supervision, continuous help, encouragement throughout this work and great effort he has done in the meticulous revision of the whole work. It is a great honor to work under his guidance and supervision.*

I am also grateful to ***Prof. Dr. Khaled Hassan Saad*** *ass. professor of anesthesia and intensive care, faculty of medicine, Ain Shams University for his guidance, continuous assistance and sincere supervision of this work.*

I would like also to express my sincere appreciation and gratitude to ***Dr. Noha Sayed*** *lecturer of anesthesia and intensive care, faculty of medicine, Ain Shams University, for her continuous directions and support throughout the whole work.*

Last but not least, I dedicate this work to my family, whom without their sincere emotional support, pushing me forward this work would not have ever been completed.



Introduction

Cardiovascular surgery with the use of cardiopulmonary bypass (CPB) is a common and life-saving procedure. It is the most frequent major surgical procedure performed in hospitals worldwide, with well over one million operations undertaken each year **(Albert and Antman, 2003).**

Acute kidney injury (AKI), previously referred to as acute renal failure or kidney failure, is a frequent and serious complication encountered in 1–5% of patients requiring renal replacement therapy (RRT), or 20–50% of patients developing acute increases in serum creatinine after CPB **(Conlon et al., 1999).**

Several general mechanisms have been implicated in the pathogenesis of cardiovascular surgery–associated AKI. Available evidence suggests that they are likely to involve the following mechanisms, processes, factors and pathways: toxins, metabolic factors, ischemia-reperfusion, neurohormonal activation, inflammation and oxidative stress **(Bellomo et al., 2008).**

In clinical practice, the diagnosis of AKI is based on an increase in serum creatinine and decrease in urine output, with the latter being highly variable due to the use of fluid infusion and loop diuretics. Several biomarkers have been recently investigated as possible tools for the early detection of AKI. Among these biomarkers particularly promising results have been reported for neutrophil gelatinase-associated lipocalin (NGAL), urine interleukin 18 (IL-18), and cystatin C **(Bennett et al., 2008).**

The conduct of CPB during cardiac surgery may affect the incidence of post-operative ARF. Limiting the duration of

CPB and maintaining adequate flow and perfusion pressure are of primary importance. Several other strategies related to the management of the CPB circuit may reduce renal injury, including avoidance of excessive haemodilution, avoidance of red cell transfusion, extracorporeal leucodepletion, and haemofiltration hence off-pump surgery may theoretically offer renal protection. However, the evidence that off-pump coronary artery bypass graft (OPCABG) surgery reduces renal morbidity is conflicting **(Wijeysundera et al., 2005).**

The prevention of further damage to the kidney directed at its underlying cause is the cornerstone in the management of established AKI after CPB. Early diagnosis of AKI using novel renal biomarkers may facilitate specific measures particularly in the setting of cardiovascular surgery using CPB where the timing of the injurious event to the kidney is known. By then, treatment of AKI remains largely supportive until renal function recovers **(Bellomo et al., 2007).**

Aim of the work

The aim of this work is to shed light on acute kidney injury that might be associated with cardiac surgery, its pathophsiology, risk factors, perioperative renal protection and different ways suggested for management.

Pathophysiology and risk factors

Perioperative renal failure is not an uncommon clinical problem after major cardiovascular surgery and relentlessly continues to be associated with poor outcomes; mortality rates for new patients requiring dialysis are similar to several decades ago. Barriers that have precluded effective clinical studies are caused in part by inconsistencies in defining the entity and an incomplete understanding of the pathophysiology in the clinical setting, both of which contribute to the lack of success in prevention and treatment of this disease (**Bouman et al., 2010).**

The term acute kidney injury (AKI) was adopted in by the American Society of Nephrology Renal Research Group to reflect the entire spectrum of the disease from minimal elevations in serum creatinine to anuric renal failure, from functional deviations to structural changes, and from prerenal azotemia to acute tubular necrosis (**Dennen et al., 2010).**

A consensus definition of AKI was proposed by the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) group, which published a classification system for AKI based on changes in serum creatinine and/or urine output criteria. This is a 5-stage classification, the first 3 of which define grades of increasing severity of AKI (risk, injury, and failure) on the basis of changes of serum creatinine or glomerular filtration from baseline as well as a decline in urine output. The last 2 stages are outcome variables (loss and end-stage kidney disease), thus the acronym RIFLE classification (**Bellomo et al., 2010).**

These criteria have since been modified by the Acute Kidney Injury Network (AKIN), which proposed a timeframe of 48 hours within which AKI has to occur and 3 classes describing increases in serum creatinine relative to baseline . In