



Edema in Intensive Care Unit

Essay

*Submitted for Partial Fulfillment of
Master Degree in Internal Medicine*

Presented By

Hussein Sayed Hussein

M. B. B. Ch.

*Faculty of Medicine
Ain Shams University*

Under Supervision of

Prof. Dr. Mohamed El Tayeb Nasser

*Professor of Internal Medicine & Nephrology
Faculty of Medicine - Ain Shams University*

**Prof. Dr. Howaida Abdel-Hamid
El Shinawy**

*Professor of Internal Medicine & Nephrology
Faculty of Medicine - Ain Shams University*

Dr. Osama Mohamed Mahmood

*Assistant Professor of Internal Medicine & Nephrology
Faculty of Medicine - Ain Shams University*

*Faculty of Medicine
Ain Shams University*

2007



كلية الطب

الأوديميا في مرضى العناية المركزة

مقالة مقدمة من

طبيب / حسين سيد حسين

بكالوريوس الطب و الجراحة – جامعة عين شمس

توطئة للحصول على درجة الماجستير في أمراض الباطنة العامة

تحت إشراف

أستاذ دكتور / محمد الطيب ناصر

أستاذ أمراض الباطنة العامة و الكلى

كلية الطب – جامعة عين شمس

أستاذ دكتور / هويدا عبد الحميد الشناوي

أستاذ أمراض الباطنة العامة و الكلى

كلية الطب – جامعة عين شمس

دكتور / اسامة محمد محمود

أستاذ مساعد أمراض الباطنة العامة و الكلى

كلية الطب – جامعة عين شمس

كلية الطب

جامعة عين شمس

2007



ACKNOWLEDGEMENT



First and foremost, I thank *Allah*, who gave me the strength to accomplish this work.

Words can not express my sincere gratitude and appreciation to *Prof. Dr. Mohamed El Tayeb Nasser*, Professor of Internal Medicine & Nephrology, Faculty of Medicine, Ain Shams University; I had the honor to work under his supervision, I appreciate his generous guidance, Keen interest and precious time he offered me throughout this study. His scientific advices were kindly given to me and are beyond acknowledgement.

I would like to express my sincere indebtedness and profound gratitude to, *Prof. Dr. Howaida Abdel-Hamid El Shinawy*, Professor of Internal Medicine & Nephrology, Faculty of Medicine, Ain Shams University, for her continuous guidance, valuable suggestions and keen supervision throughout work.

I wish also to express my deep gratitude to *Dr. Osama Mohamed Mahmood*, Assistant Professor of Internal Medicine & Nephrology, Faculty of Medicine, Ain Shams University, for his continuous support, valuable remarks meticulous supervision and for offering me much of his time and effort throughout this study.

LIST OF CONTENTS

<i>Introduction</i>	<i>I-III</i>
<i>List of abbreviations</i>	<i>IV-XI</i>
<i>List of figures</i>	<i>XII-XIII</i>
<i>List of tables</i>	<i>XIV--XV</i>
<i>Review of literature</i>	

<u>Introduction to edema</u>	<u>1-15</u>
-------------------------------------	--------------------

- *Definition of edema*
- *Intracellular edema*
- *Extracellular edema*
- *Generalized edema and localized edema*
- *Major causes of edema according to primary mechanisms*
- *Nonpitting edema*
- *Pathophysiology of edema formation*
- *Capillary hemodynamics*
- *Renal sodium retention*
- *The compensated state*
- *Edema formation*
- *Safety factors that normally prevent edema*

<u>Causes, pathophysiology and management of edema in the intensive care unit</u>	<u>16-197</u>
--	----------------------

Critical care patients and intensive care unit

1. *Fluid resuscitation and the genesis of edema*
2. *Reduced muscle pump activity & DVT*
3. *Mechanical ventilation*
4. *Heart failure*
5. *Renal edema and acute renal failure*
6. *Liver cell failure*
7. *Drug-induced edema*
8. *Sepsis*

9. Hypoalbuminemia
10. Idiopathic edema
11. Refeeding edema
12. Venous Insufficiency
13. Laryngeal edema

Management of edema-----198-234

- Clinical manifestations and diagnosis of edema
 - Pattern of distribution of edema
 - Distribution of edema and central (jugular) venous pressure
- General principles of therapy
- The consequences of the removal of edema fluid
- Mechanism of action of diuretics
- Loop diuretics
- Thiazides
- Potassium-sparing diuretics
- Acetazolamide
- Mannitol
- Efficacy OF diuretics
- Use of diuretics
- Diuretic dose
- Complications of diuretics
- Major types of side effects related to loop diuretic
- Complications of mannitol therapy
- Refractory edema
- Management of refractory edema
- Hemofiltration

Summary and recommendations-----235-239

References ----- 240-268

Arabic summary-----

Introduction

Edema is the result of an imbalance in the filtration system between the capillary and interstitial spaces. Forces such as an elevation in capillary hydraulic pressure, an increase in capillary permeability or interstitial oncotic pressure, or a reduction in plasma oncotic pressure increase net filtration. Therefore edema means swelling in the small spaces that surround the body tissues and organs and it can occur nearly anywhere in the body (**Rose, 2004**).

Patients in emergencies necessitating treatment in the intensive care unit often develop generalized gross edema. The usual scenario is that in the emergency situation characterized by hypotension and (impending) organ failure, large amounts of fluids are administered that subsequently cannot be excreted adequately, even if the emergency situation subsides to a more stable condition. Therefore, the kidneys play a key role in regulating extra cellular fluid volume by adjusting sodium and water excretion (**Hinds & Watson, 1999**).

A number of different problems can produce these conditions and cause edema to occur, for example, renal failure, liver failure or heart failure. Some of the most common are conditions unrelated to any specific disease, such as, decreased muscle pump activity, mechanical

ventilation and septicaemia (**Koomans & Boer, 1997**).

Treatment of edema consists of reversing the underlying disorder (if possible), restricting dietary sodium to minimize fluid retention, and, usually, employing diuretic therapy. This approach highlights the need to establish a diagnosis and to use non-pharmacologic approaches when appropriate, rather than resorting to the immediate use of diuretics (**Rose, 2004**). On the contrary, diuretics represent one of the most commonly used agents in the intensive care unit and fluid balance (**Haji, 2005**).

Aim of the essay is to:

- Review different etiologies, pathophysiology and management of edema in ICU.
- Outline a suggested protocol for analyzing edema in ICU setting.

List of abbreviations

ACTH	Adrenocorticotrophic hormone
ACE	Angiotensin converting enzyme
Acta Anaesthesiol Scand	Acta Anaesthesiologica Scandinavica
ADAMTS13	Von Willebrand factor cleaving protease
ADH	Antidiuretic hormone
ADHERE	The Acute Decompensated Heart Failure National Registry
AIDS	Acquired immunodeficiency syndrome
AJR Am J Roentgenol	American Journal of Roentgenology
ALF	Acute liver failure
ALI	Acute lung injury
ALT	Alanine aminotransaminase
Am Heart J	American Heart Journal
Am J Cardiol	American Journal of Cardiology
Am J Gastroenterol	American Journal of Gastroenterology
Am J Hematol	American Journal of Hematology
Am J Kidney Dis	American Journal of Kidney Diseases
Am J Med	American Journal of Medicine
Am J Med Sci	American Journal of the Medical Sciences
Am J Obstet Gynecol	American Journal of Obstetrics and Gynecology
Am J Pathol	American Journal of Pathology
Am J Physiol	American Journal of Physiology
Am J Respir Crit Care Med	American Journal of Respiratory and Critical Care Medicine
ANA	Antinuclear antibodies
Anaesth Intensive Care	Anaesthesia and Intensive Care
Ann Emerg Med	Annals of Emergency Medicine
Ann Intern Med	Annals of Internal Medicine
Ann Pharmacother	Annals of Pharmacotherapy
Ann Surg	Annals of Surgery
Ann Thorac Surg	Annals of Thoracic Surgery
ANP	Atrial natriuretic peptide

Anti-HAV Ig M	Anti-hepatitis A virus immunoglobulin M
Anti-HBc Ig M	Anti-hepatitis B core immunoglobulin M
Anti-HCV	Anti-hepatitis C virus
Anti-HEV	Anti-hepatitis E virus
APII	The Acute Physiologic and Chronic Health Evaluation
aPTT	Activated partial thromboplastin time
ARBS	Angiotensin receptor blockers
Arch Dis Child	Archives of Disease in Childhood
Arch Intern Med	Archives of Internal Medicine
Arch Neurol	Archives of Neurology
Arch Surg	Archives of Surgery
ARDS	Adult respiratory distress syndrome
ARF	Acute renal failure
Artif Organs	Artificial Organs
ASAIO J	ASAIO Journal
ASAIO Trans	ASAIO Transactions
ASMA	Antismooth muscle antibodies
AST	Aspartate aminotransaminase
ASVT	Axillosubclavian venous thrombosis
AT1receptors	Angiotensin type 1 receptors
ATN	Acute tubular necrosis
AVP	Arginine vasopressin
Best Pract Res	Best Practice and Research.
Clin Endocrinol Metab	Clinical Endocrinology and Metabolism
Blood Purif	Blood Purification
Blood Rev	Blood Reviews
BMJ	British Medical Journal
BNP	Brain natriuretic peptide
BP	Blood pressure
Br J Anaesth	British Journal of Anaesthesia
Br J Haematol	British Journal of Haematology
Br J Surg	British Journal of Surgery
Br Med J	British Medical Journal
BUN	Blood urea nitrogen
πcap	The capillary oncotic pressures
Cardiol Clin	Cardiology Clinics

CAVH	Continuous arteriovenous hemofiltration
CAVHD	Continuous arteriovenous hemodialysis
CCLS	Critical care liaison service
CHF	Congestive heart failure
Circ Res	Circulation Research
Circ Shock	Circulatory Shock
Cleve Clin J Med	Cleveland Clinic Journal of Medicine
Clin Chem	Clinical Chemistry
Clin Chem Lab Med	Clinical Chemistry and Laboratory Medicine
Clin Chest Med	Clinical Chemistry Medicine
Clin Intensive Care	Clinical Intensive CareClin.
Clin Nephrol	Clinical Nephrology
Clin Obstet Gyne	Clinical Obstetrics and Gynecology
Clin Pharmacokinet	Clinical Pharmacokinetics
Clin Pharmacol Ther	Clinical Pharmacology and Therapeutics
CLOT trial	A multicenter international randomized clinical trial
Congest Heart Fail	Congestive Heart Failure
Contrib Nephrol	Contributions to Nephrology
COP	Colloid osmotic pressure
CPE	Cardiogenic pulmonary edema
CPP	Cerebral perfusion pressure
Crit Care Clin	Critical Care Clinics
Crit Care Med	Critical Care Medicine
CRRTs	Continuous renal replacement therapies
CT	Computed tomography
Curr Heart Fail Rep	Current Heart Failure Reports
Curr Hypertens Rep	Current Hypertension Reports
Curr Opin Hematol	Current Opinion in Hematology
Curr Opin Pulm Med	Current Opinion in Pulmonary Medicine
CVP	Central venous pressure
CVVH	Continuous venovenous hemofiltration

Dan Med Bull	Danish Medical Bulletin
Dermatol Surg	Dermatologic Surgery
DIC	Disseminated intravascular coagulopathy
Dig Dis Sci	Digestive Diseases and Sciences
DKA	Diabetic ketoacidosis
Do2	Oxygen delivery
Dtsch Med Wochenschr	Deutsche Medizinische Wochenschrift
DVT	Deep vein thrombosis
ECF	Extracellular fluid
ESRD	End-stage renal disease
EtCo2	End-tidal carbon dioxide
Eur Heart J	European Heart Journal
Eur J Cardiothorac Surg	European Journal of Cardio-Thoracic Surgery
Eur J Vasc Endovasc Surg	European Journal of Vascular and Endovascular Surgery
Eur Respir J	European Respiratory Journal
EWS	Early warning scoring system
FeNa (%)a	$((U\text{ Na}/S\text{ a})/(U\text{ creatinine}/S\text{ creatinine})) \times 100$
FFP	Fresh frozen plasma
FHF	Fulminant hepatic failure
FiO2	fractional inspired oxygen concentration;
FMLP	fMet-Leu-Phe, a three amino acid chemotactic peptide in the bacterial cell walls
Gastroenterol Clin North Am	Gastroenterology Clinics of North America
GFR	Glomerular filtration rate
GGT	Gamma glutamyltransferase
HAPE	High altitude pulmonary edema
HBsAg	Hepatitis B virus surface antigen
HE	Hepatic encephalopathy
Health Serv Res	Health Services Research
HELLP syndrome	Hemolysis with a microangiopathic blood smear, elevated liver enzymes, and a low platelet count
HF	Heart failure
HIV	Human immunodeficiency virus
HUS	Hemolytic uremic syndrome
ICP	Intracranial pressure

ICU	Intensive care unit
πif	The interstitial fluid oncotic pressures
IGF-1	Insulin-like growth factor-1
IGIV(IVIG)	Immunoglobulin intravenously
IL-1ra	Interleukin 1ra
IL-6	Interleukin 6
INR	The International Normalized Ratio
Int J Artif Organs	International Journal of Artificial Organs
Intensive Care Med	Journal of Intensive Care Medicine
Isr J Med Sci	Israel Journal of Medical Sciences
IVC	Inferior vena cava
J Am Coll Cardiol	Journal of the American College of Cardiology
J Am Soc Nephrol	Journal of the American Society of Nephrology
J Appl Physiol	Journal of Applied Physiology
J Biol Chem	Journal of Biological Chemistry
J Card Fail	Journal of Cardiac Failure
J Clin Apheresis	Journal of Clinical Apheresis
J Clin Invest	Journal of Clinical Investigation
J Clin Oncol	Journal of Clinical Oncology
J Hepatol	Journal of Hepatology
J Lab Clin Med	Journal of Laboratory and Clinical Medicine
J Natl Med Assoc	Journal of the National Medical Association
J Thromb Haemost	Journal of Thrombosis and Haemostasis
J Urol	Journal of Urology
J Vasc Surg	Journal of Vascular Surgery
JVP	Jugular-venous pulsation
Kidney Int	Kidney International
KIM-1	Kidney injury molecule 1
Klin Wochenschr	Klinische Wochenschrift
Kt/V	Dialzer clearance of urea K (obtained from the manufacturere in milli/min, and periodically measured & verified by dialysis team) multiplied by duration of dialysis treatment (t,in min) divided by volume of distribution of urea in the body(V,in milli)
LMW heparin	Low molecular weight heparin
Lp	The unit permeability of the capillary wall
LPS	Lipopolysaccharides

LV	Left ventricle
LVH	Left ventricle hypertrophy
MAP	Mean arterial pressure
Mayo Clin Proc	Mayo Clinic Proceedings
MELD	Model for End-Stage Liver Disease
MET	Medical emergency team
MEWS	Modified early warning score
MI	Myocardial infarction
Micovasc Res	Microvascular Research
MODS	Multiple organ dysfunction syndrome
N Engl J Med	New England Journal of Medicine
Na U	Urinary Sodium
NAC	N acetylcystiene
Nephrol Dial Transplant	Nephrology, Dialysis, Transplantation
Neurochem Int	Neurochemistry International
New Horiz	New Horizons
NGAL	Neutrophil gelatinase-associated lipocalin
NO	Nitric oxide
NPE	Neurogenic pulmonary edema
NPPV	Noninvasive positive pressure ventilation
Osm U	Urine Osmolarity
PART	Patient at risk team
Pcap	The capillary hydraulic pressures
PD	Peritoneal dialysis
PE	Pulmonary embolism
Pediatr Nephrol	Pediatric Nephrology
PEEP	Positive end- expiratory pressure
PGE2	Prostaglandin E2
PHT	Portal hypertension
Pif	The interstitial fluid hydraulic pressures
PMNs	Polymorphonuclear neutrophil leukocytes
PPI	Proton pump inhibitor
PT	Prothrombin time
PTT	Partial thromboplastin time
PZA	Pyrazenamide
Q J Med	Quarterly Journal of Medicine

QJM	Quarterly Journal of Medicine
RAAS	Renin-angiotensin-aldosterone system
RBF	Renal blood flow
Ren Fail	Renal Failure
RR	Relative risk
S	The surface area available for fluid movement
s	Reflection coefficient of proteins across the capillary wall (with values ranging from 0 if completely permeable to 1 if completely impermeable)
s.cr	Serum creatinine
SaO₂	Arterial oxygen saturation
Semin Hematol	Seminars in Hematology
Semin Liver Dis	Seminars in Liver Disease
Semin Nephrol	Seminars in Nephrology
SIADH	Syndrome of inappropriate antidiuretic hormone
SIRS	Systemic inflammatory response syndrome
South Med J	Southern Medical Journal
SpO₂	Pulse oximeter oxygen saturation
Svo₂	Venous oxygen saturation
SVR	Systemic vascular resistance
TACO	Transfusion-associated volume/circulatory overload
Ther Apher	Therapeutic Apheresis
Thromb Haemost	Thrombosis and Haemostasis
TIPS	Transjugular intrahepatic portosystemic shunt
TNF-a	Tumor necrosis factor a
tPA	Tissue-type plasminogen activator
TRALI	Transfusion-related acute lung injury
Transplant Proc	Transplantation Proceedings
Trop Gastroenterol	Tropical Gastroenterology
TSH	Thyroid-stimulating hormone
TTP	Thrombotic thrombocytopenic purpura
U/S creatinine	Urine creatinine/Serum creatinine
U/S osmolarity	Urine osmolarity/Serum osmolarity