EXTRACORPOREAL BLOOD PURIFICATION IN ICU

Essay

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Heba Talaat Al-Sheshtawy

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List of Abbreviations

ADQI: Adequate dialysis quality initiative

AKI: Acute kidney injury

ARF: Acute renal failure

BAL: Biological artificial liver

CAVH: Continuous arteriovenous hemofilteration

CAVHD: Continuous arteriovenous hemodialysis

CAVHDF: Continuous arteriovenous hemodiafilteration

CHF: Continuous hemofilteration

CIDP: Chronic inflammatorydemyelnating polyradiculoneuropathy

CKD: Chronic kidney disease

CRRT: Continuous renal replacement therapy

CVC: Central venous catheter

CVVH: Continous venovenous hemofilteration

CVVHDF: Continuous venovenous hemodiafilteration

ECAD: Extracorporeal albumin dialysis

EDD: Extended daily dialysis

ELAD: Extracorporeal liver assist device

ESKD: End stage kidney disease

FDA: Food and drug administration

FSGS: Focal segmental glomeruloscelerosing

GBS: Guillian barre syndrome

HD: Hemodialysis

HE: Hepatic encephalopathy

HF: Hemofilteration

HRS: Hepatorenal syndrome

ICU: Intensive care unit

IHD: Intermittent hemodialysis

ITP: Immune thrombocytopenic purpura

LMW: Low molecular weight

MARS: Molecular adsorbent recirculating system

MARS: Molecular adsorbent recirculating system

MG: Myasthenia gravis

MS: Multiple scelerosis

MV: Molecular weight

NMO: Neuromyelitiscoptical

PD: Peritoneal dialysis

RRT: Renal replacement therapy

SCUF: Slow continuous ultrafitration

SIRS: Systemic inflammatory response syndrome

SLED: Sustained low efficiency dialysis

TMP: Trans membranous pressure

TTP: Thrombotic thrombocytopenic purpura

UFR: Ultrafilteration rate

UV: Ultraviolet

Introduction

Critical care has dramatically evolved over the last three decades and produced effective treatments of diseases that were once unequivocally and hopelessly fatal. What were the events that mediated this evolution? Certainly, a better understanding of pathophysiology, especially at the molecular level is one event. Certainly, new pharmaceuticals targeting various mechanisms of disease are another event. But without question, technological innovation is an event that has exerted an extraordinary impact on modern critical care **(Scurlock et al., ٢٠٠٩).**

The replacement of renal function by hemodialysis (HD) demonstrated for the first time that at least the most vital functions of a complex organ could be replaced by a man-made device. The Founding Father of dialysis is the Scottish chemist Thomas Graham who in ١٨٦١ found that colloid and crystalloid substances contained in fluids could be separated by diffusion of crystalloids through vegetable parchment acting as a semipermeable membrane. He coined this phenomenon as "dialysis" **(Jacobs, ٢٠٠٩).**

Extracorporeal therapies are a procedure in which the blood of a patient is passed through an extracorporeal medical device which separates components of blood and designed to remove substances from the circulation to treat a disease. It is a general term which includes broad and exemplary technological advances as hemodialysis, hemofiltration, hemoadsorption, albumin dialysis or combinations of any of these. These modalities have saved many lives, but this benefit has a price **(House & Ronco, ٢٠٠٨; Szczepiorkowski et al., ٢٠١٠).**

The pathogenesis of each of organ failure is complex and variable, brought about by a variety of underlying conditions, the potential to improve patient outcomes by simultaneously targeting multiple pathways can perhaps best be realized by blood purification **(Wago & Shimooka, ٢٠١١).**

Unlike drug strategies, which are usually limited to one component of these complex networks, blood purification is, by its very nature, broad spectrum and self regulating **(Lu et al., ٢٠٠٦).**

Aim of the work

The aim of the essay proposal is to through more light on the emersion of new technological innovation in modern critical care concerning extracorporeal blood purification. Demonstration of its various types, explain its role and impact on different diseases.

History &evolution of extracorporeal blood purification

Introduction:

For many years, the term 'blood purification' has been used to indicate renal replacement therapy directed at chronic patients with end-stage kidney disease. The level of application and understanding of extracorporeal therapies for renal replacement and support have however been expanded in recent years, and today a new area of clinical application and research is the use of blood purification techniques in the critically ill.

This evolution has required an expansion of the multidisciplinary approach to critical care and nephrology, resulting in a brand new specialty called 'critical care nephrology' **(Ronco & Bellomo, ١٩٩٨) [a].**

At the same time, the multiple applications of extracorporeal therapies in critically ill patients have made possible the evolution of management of such patients using a new therapeutic strategy called 'multiple organ support therapy'. In these circumstances, the extracorporeal therapies are called upon to support many organs other than the kidney and for more than just the manipulation or correction of circulating blood composition **(Ronco & Bellomo, ١٩٩٨) [b].**

For many years, renal replacement therapy has been a technique used by nephrologists, while intensive care and nephrology were regarded as two separate specialities.

Today, the complexity of acute kidney injury syndromes, the concomitant presence of sepsis and the frequent occurrence of multiple organ dysfunction represent a condition in which severity of disease must

be approached by a multidisciplinary task force with a high level of clinical and logistical integration **(fig. ١) (Ronco & Bellomo, ٢٠٠٢).**

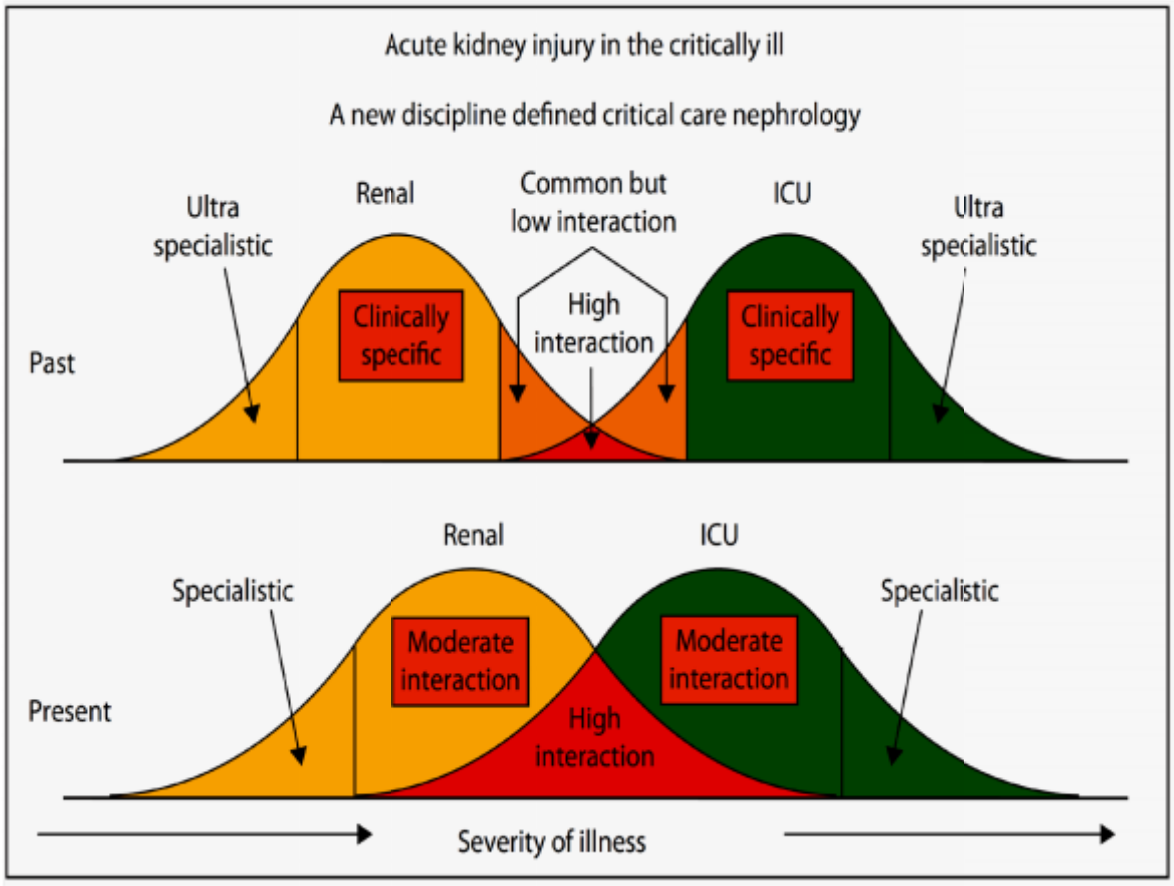

Fig ١: In the past, the interaction between nephrology and intensive care was minimal. Today, there is continuous interaction with several moments of high interaction due to common patients and complex syndromes.

Therapeutic apheresis (blood purification) is a collective term for a variety of in vivo medical techniques that separate plasma or a cellular component from blood or other body fluids such as thoracic duct lymph. The separated element or elements may be discarded or may be treated and used to correct a pathologic condition. Techniques currently in use include plasmapheresis, plasma exchange, extracorporeal plasma adsorption and immunoadsorption, and cytopheresis. A broad definition

of therapeutic apheresis can be extended to include hemodialysis, various modes of hemofiltration(HF) and hemodiafilteration **(Kodama, ١٩٩٧).**

Origins of dialysis:

Many have played a role in developing dialysis as a practical treatment for renal failure, starting with Thomas Graham of Glasgow, who first presented the principles of solute transport across a semi permeable membrane in ١٨٥٤ **(Graham, ١٨٥٤).**

The artificial kidney was first developed by Abel, Rountree and Turner in ١٩١٣ **(Haas, ١٩٤٤),** the first hemodialysis in a human being was by Hass (February ٢٨, ١٩٢٤) and the artificial kidney was developed into a clinically useful apparatus by Kolff in ١٩٤٣ - ١٩٤٥. This research showed that life could be prolonged in patients dying of renal failure **(Shaldon, ٢٠٠٢).**

Dr. Willem Kolff was the first to construct a working dialyzer in ١٩٤٣. The first successfully treated patient was a ٦٧-year-old woman in uremic coma who regained consciousness after ١١ hours of hemodialysis. At the time of its creation, Kolff's goal was to provide life support during recovery from acute renal failure.

By the ١٩٥٠s, Willem Kolff's invention of the dialyzer was used for acute renal failure, but it was not seen as a viable treatment for patients with stage ٥ chronic kidney disease (CKD) for two reasons. First, they thought no man-made device could replace the function of kidneys over the long term. In addition, a patient undergoing dialysis suffered from damaged veins and arteries**(Kjellstrand, ١٩٩٧).**

History of Continous Renal Replacement Therapy(CRRT):

The history of HF began in the year ١٩٤٧, the time when **Alwall, ١٩٤٤;** succeeded in removing excess water through cellulosic membrane

only applying negative pressure. And the first clinical trial was done by **Inoh et al., ١٩٥٨;** who developed artificial kidney in ١٩٥٨. Utilizing 'dog lungs' as membrane, they succeeded in saving patients.

In ١٩٦٧, Henderson et al., performed an HF experiment with an animal using polysulfone membrane; they undertook the first clinical trial in ١٩٧١ **(Hamilton et al., ١٩٧١).**

In the following year, Kobayashi et al., ١٩٧٢; proposed a new method and termed it the 'extracorporeal ultrafiltration method'. Using a Kiil dialyzer with neither dialysis fluid nor substitution fluid, they removed excess water from a patient's body only by ultrafiltration.

In ١٩٧٧, Dr. Peter Kramer was the first to describe such type of therapy in the literature. It was named CAVH (Continuous Arterio-Venous Hemofiltration). The blood was moved from an artery to a vein through a hemofilter.

Ultrafiltration rate was controlled by raising and lowering the drain bag.

Because of hypotension experienced by critically ill patients the blood flow of AV method, where the difference of pressure between artery and venous vessels is used to create the flow, is low and limits the volume of ultrafiltrate which can be obtained.

In ١٩٨٢ FDA (Food and Drug Administration) approves CAVH.

From the early ٨٠'s a blood pump and a double-lumen catheter in a large vein are used to provide a consistent blood, and thus ultrafiltration flow. This so called Veno-Venous technique has been since then been adopted and improved to become the most standard in CRRT.

In the ٩٠'s the first fully automatic machines are made and become immediately popular in intensive care settings.