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Chapter

Introductory Chapter: Updates on Hemodialysis

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1. Introduction

Despite the significant improvements in hemodialysis (HD) techniques over the past 40 years, patients on this therapy still suffer from the burden of HD-associated symptoms, vascular access-related issues, acute and chronic complications, poor quality of life, and the mortality rate remains unacceptably elevated [1, 2]. The European Renal Association (ERA) and the United States Renal Data System (USRDS) showed that the 5-year survival rate for patients on HD is close to only 50%, which is worse than patients with breast cancer, prostate cancer and almost like or worse than colon cancer [3–6].

The retention of large-size uremic toxins (e.g., proinflammatory cytokines, alpha 1-microglobulin, YKL-40, and kappa and lambda free light chains) has been associated with inflammation, atherosclerosis and vascular calcification, cardiovascular disease, and increased risk of mortality [7]. These uremic toxins have also been associated with poor quality of life, such as late recovery time post-HD session, impaired physical function, moderate-to-severe pruritus, and restless legs syndrome [8]. These drawbacks of HD treatment demonstrate the unmet needs in the current or conventional HD modalities.

2. Uremic toxins and hemodialysis techniques

The new medium cut-off membrane/dialyzer, with its larger pore size, lower wall thickness, and smaller inner diameter of hollow fibers, has significantly improved the clearance of the large-size uremic toxins in safe, simple, and effective technique, especially when compared to conventional hemodialysis techniques [9]. For example, the low-flux HD can remove small soluble solutes less than 500 Dalton (Da), such as urea and creatinine, whereas high-flux HD is capable of efficiently removing molecules less than 15,000 Da. Diffusion is the major contributor to the clearance of small-size molecules, but convection, as in online hemodiafiltration (HDF), is required for the efficient removal of large-size molecules, especially those above 25,000 Da [7]. Randomized controlled trials have shown the effectiveness of online HDF not only in its ability to remove large-size uremic toxins but to improve the quality of life [10] and to significantly reduce the cardiovascular and all-cause mortality, especially if the used prescribed convection volume equals to or exceeds 23 liters/1.73 m^2/session [11]. However, successful implementation of online HDF is demanding. For example, it requires a special HD machine that has the ability to mix solutions online, a powerful high-flux dialyzer, functional vascular access with a blood flow rate of 350–400 ml/

minute (difficult with central venous catheters or not properly functioning arteriovenous fistula or graft), consumption of large volume of water (almost double what is needed for conventional HD), ultrapure water (free from bacteria and endotoxin), frequent monitoring of water quality, training of medical and nursing staff (especially when the turnover is frequent) and achievement of the prescribed convective volume [12].

The actual value of the medium cut-off membrane/dialyzer is its ability to perform diffusion and convection with fluid replacement (internal filtration) internally simulating, and probably more effective than, online HDF, without the need for external replacement fluids [13], using a basic HD machine with a blood flow rate of 250–300 ml/minute [14], and standard water quality (ISO11663 or ANSI/AAMI RD62) [15–21] for conventional HD over the 4-hours dialysis session. This modality of HD is referred to as HDx or expanded hemodialysis [9]. HDx therapy has been shown to remove effectively larger-size uremic toxins [22], improvement of quality of life [23–26], reduction in HD-related medications (e.g., erythropoietin and iron) [27, 28], and a significant decrease in hospitalization rate [29, 30] and nonfatal cardiovascular disease [18].

3. Complications of hemodialysis

The technique of hemodialysis, especially with the recent developments in the technology of HD machines, is still associated with several acute and chronic complications, such as intradialytic hypotension, hypertension, fluid retention, risk of bleeding (among other hematological complications), muscle cramps, arrhythmias, and sudden cardiac death. "*Updates on Hemodialysis*" reviews and updates the reader on these complications, and some iatrogenic errors such as hypernatremia, iron overload, pseudoaneurysm, and air embolism. Hemodialysis patients also suffer from and are affected by different psychological stresses upon starting dialysis and during the course of treatment, which affect different lifestyle changes. The "*Updates on Hemodialysis*" describes the most common psychosocial issues among patients on hemodialysis treatment.

4. Vascular access

There are three types of vascular access. These are arteriovenous fistula, arteriovenous graft, and central venous catheters. Each of these has its uses and advantages and disadvantages. Vascular access is the lifeline for patients in need of hemodialysis. "*Updates on Hemodialysis*" reviews the basics of perioperative anesthetic management, including the choice of anesthesia method, pre-anesthesia preparation, intraoperative and postoperative management, and the effect of choice of anesthesia on the outcomes. In addition, "*Updates on Hemodialysis*" updates the reader on recent innovations in central venous catheter's tip and coating designs, newer arteriovenous fistula access techniques, including a percutaneous endovascular method, innovations in arteriovenous graft, including drug-eluting devices that may reduce neointimal hyperplasia and bioengineered blood vessels, and arteriovenous graft/central venous catheter device, which enables bypassing vessel stenoses.

The "*Updates on Hemodialysis*" book aims at reviewing and updating the reader on understanding type, source, classification of uremic toxins, and ways of their

monitoring, HD-related complications, hypertension in HD, errors in HD practices, and psychological status of HD patients, management and innovation of vascular access techniques, resistance to erythropoietin and its prescription, and extracorporeal management of liver failure. "*Updates on Hemodialysis*" book has also focused on the recent innovation in dialysis membranes/dialyzers, particularly the medium cut-off membrane and its ability to remove the larger-size uremic toxins more efficiently in a HD modality known as expanded hemodialysis (HDx).

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