Chemical and microbial quality of water in different pretreatment stages and input water to dialysis devices: a case study on comparison with AAMI Standard, Iran

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Abstract

Chemical and biological quality of input water to the dialysis devices is very important for hemodialysis patients. The aim of this study was evaluating water entering to the dialysis devices and comparison international standard. In this study five dialysis devices were randomly selected from hemodialysis wards of Kermanshah’s Imam Reza hospital and the most important chemical parameters (calcium, magnesium, sodium, potassium, nitrate, sulfate, fluoride, and chlorate) and a microbial parameter (bacteria) of water entering the dialysis devices was measured during one month. Two reverse osmosis (RO) systems were located before each dialysis device as pretreatment. The samples were taken from input and of RO systems. The sampling was conducted twice a week and 120 samples (40 samples from input of first RO system or tap water, 40 samples from output of first RO or input of second RO system, and 40 sample from output of second RO system or input of dialysis device) were taken totally. The results show that all measured chemical and microbial parameters (except calcium with no verification test) in water entering all dialysis devices were consistent with AAMI standards. Also evaluated parameters 1053 (except magnesium with no verification test) in all drinking water samples were consistent with drinking water standard. Based on the results, it could be said that the proper performance of RO devices, purified water conservation storage and transportation has been caused the proper quality of water entering dialysis device and its consistent to both AAMI and endotoxin standards.

Keywords: chemical and microbial quality; dialysis device; reverse osmosis; hospital

Introduction

Dialysis process is used for person with kidney disease that conducts many kidneys task and provides normal conditions for patients. In this regard, it could be said that renal failure decrease ability to detoxify the blood by the kidneys. For this reason, the patient whom faced
with this problem needs regular hemodialysis in order to be alive (Brunet and Berland, 2000; Pérez et al., 2008). A normal person require 2 liter per day drinking water. While hemodialysis patients need 300 liter water at any time that they are on hemodialysis. A considerable note is that drinking water is passed through the digestive system before entering to blood. So, the contaminant of drinking water is removed by organs before blood circulation system. While on hemodialysis the contaminants of dialysis fluids are directly entered the blood. So, the quality of applied water for dialysis especially chemical quality is very critical (D’haese and De Broe, 1996; Hoenich et al., 2006). Dialysis fluid consisted of condensed electrolyte of raw materials mixture and water with the ratio of 1/34.

Condensed water is produced commercially with the same quality and it highly controlled, but the used water might have different quality. The conventional tap water can enter toxic substances to dialysis liquid and then to patients’ blood. Because of this the water quality that used for dialysis solution preparation is very important (Organization, 2004). There is a pretreatment system (mainly RO system) before dialysis device that provide water with proper quality (based on the standard) for entering to dialysis device (Hoenich et al., 2006). Most of the experts believed that some unpleasant event in dialysis wards is due to improper performance of pretreatment system and as a result the improper water quality that enters the dialysis device (Amato, 2001).

There are different compounds and chemical elements such as calcium, magnesium, sulfate, aluminum, chloride, fluoride etc. in tap drinking water. Also some toxic substances such as cu, zinc, Pb are added to the water due to distribution network failure. For this reason, improper quality and high salts and contaminants in used water can be very harmful for dialysis patient (Marjani and Vaghari, 2005). For example, high level if fluoride in water is associated with rickets incidents (Baseri et al., 2013). Also existing nitrate in dialysis water may cause methemoglobinemia disease in children less than six month (Moghaddamnia, 1998). So, the standard tap drinking water without additional post treatment is not suitable for dialysis device and there are a lot of risks with it. For this reason, the required water for dialysis device must be purified before that to prevent risk that is related to chemical quality of water and there is a need for regular monitoring of the quality of hemodialysis devices input water (Davidovits et al., 2003). Because of dialysis water quality importance in term of chemical and biological quality and lack of study on dialysis devices input water quality of in Kermanshah’s hospital, the aim of this study is evaluating the most important chemical (calcium, magnesium, sodium, potassium, nitrate, sulfate, fluoride, chlorate) and biological (bacteria) parameters of dialysis water in Kermanshah’s Imam Reza hospital and comparing it with AAMI standard.

Materials and Methods

This descriptive-analytic study was conducted in Imam Reza hospital, Kermanshah, Iran. The five dialysis devices were selected randomly and evaluated for input water quality. The dialysis system was consisted two RO devices and final dialysis process. The sampling was done twice a week from input and output of first and second RO system. The dialysis system and sampling points were shown in figure 1. 120 samples (40 samples form input of first RO system or tap water, 40 sample from output of first RO or input of second RO system, and 40 sample from output of second RO system or input of dialysis device) were taken totally. The measured parameters were calcium, sodium,
potassium, magnesium, fluoride, chloride, nitrate, sulfate, and (hetero plate count) HPC based on standard methods for the examination of water and wastewater book (Federation and Association, 2005). The RO systems that are used as dialysis devices pretreatment have high pressure between 200-250 psi and their membrane was made from polyamide. One-sample t-test was used in a significant level (α = 0.05) by SPSS 16 software for comparing the average concentration of evaluated element with AAMI standard.

Results

The evaluated level of all chemical and microbial parameters in all samples taken from input water (except calcium in 30% of the samples) was consistent with AAMI standard (Instrumentation, 2004). Evaluated level of parameters in all tap water samples (except Magnesium) was consistent with national drinking water standard 1053 (ISIRI (1053), 1997). These results are presented in table 1. The comparative analysis of parameters in input water of dialysis devices and AAMI standard have done by one sample t-test in a significant level (α=0.05) and presented in table 2.

Discussion

Based on the results the difference of average value of all evaluated parameters (except magnesium) in tap water (first RO system input) and AMMI standard is statistically significant (p value<0.05) and the amount of all parameters are lower than AAMI standard (ISIRI (1053), 1997; Instrumentation, 2004). For Mg, although its average was more than the standard level (55 against 50 mg/l), but this difference was not statistically significant (p value > 0.05).

Due to the high quality of the raw water to the reverse osmosis system, it can be expected that reverse osmosis membranes can operate with least problem. High concentration of cations and anions in the water entering the reverse osmosis can increase maintenance costs and operation problems (Zhao and Shi, 2005).

The desirability of drinking tap water is related to water treatment plant and water resource type and is out of the hospital management duty (Organization, 2004). The results of present study in relation to dialysis devices and RO devices input water quality is consistent with other studies. Baseri et.al showed that purified tap water entering the RO devices was consistent with 1053 standard (Baseri et al., 2013). It should be noted that the difference between results of present study and Baseri et al. study may be
originated from treatment level, treatment type, and water resource type. Based on the results, the average level of evaluated parameters in both RO devices output (dialysis devices input water) except Calcium were lower than AAMI standard and this fact could be relevant to the proper performance of RO devices in reducing contaminant level and also proper quality of tap water entering the first RO devices (Zhao and Shi, 2005). Most important note is

**Table 1.** The results of chemical and biological quality of purified water and dialysis devices input water

<table>
<thead>
<tr>
<th>Parameters name</th>
<th>First RO influent</th>
<th>Standard level (1053standard)</th>
<th>First RO effluent</th>
<th>Second RO effluent</th>
<th>Input to dialyzer (AAMI)</th>
<th>Output from dialyzer (AAMI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate (mg/l)</td>
<td>226.5±25.6</td>
<td>400</td>
<td>0.009</td>
<td>6.8±0.3</td>
<td>5.5±0.4</td>
<td>100</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>5.5±1.6</td>
<td>50</td>
<td>&lt;0.001</td>
<td>0.18±0.06</td>
<td>0.25±0.12</td>
<td>2</td>
</tr>
<tr>
<td>Fluoride (mg/l)</td>
<td>0.7±0.08</td>
<td>0.7-1.5</td>
<td>0.04</td>
<td>0</td>
<td>0.2</td>
<td>1</td>
</tr>
<tr>
<td>Chlorate (mg/l)</td>
<td>0.5±0</td>
<td>0.5-0.8</td>
<td>0.045</td>
<td>0</td>
<td>0.5</td>
<td>-</td>
</tr>
<tr>
<td>Calcium (mg/l)</td>
<td>126±18.4</td>
<td>250</td>
<td>0.032</td>
<td>2.6±0.82</td>
<td>1.9±0.73</td>
<td>2</td>
</tr>
<tr>
<td>Magnesium(mg/l)</td>
<td>55±12.1</td>
<td>50</td>
<td>0.039</td>
<td>0</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Sodium (mg/l)</td>
<td>48±4.8</td>
<td>50</td>
<td>&lt;0.001</td>
<td>2.15±0.46</td>
<td>4.41±0.46</td>
<td>70</td>
</tr>
<tr>
<td>Potassium(mg/l)</td>
<td>14.6±1.8</td>
<td>-</td>
<td>-</td>
<td>3.1±0.1</td>
<td>4.7±0.1</td>
<td>8</td>
</tr>
<tr>
<td>HPC (CFU/ml)</td>
<td>84±16</td>
<td>500</td>
<td>&lt;0.001</td>
<td>8±2</td>
<td>6±1</td>
<td>200*</td>
</tr>
</tbody>
</table>

*more than 50 CFU/ml serve as a warning

**Table 2.** Comparative statistics of chemical and biological quality of dialysis devices input water with AAMI standard-2015

<table>
<thead>
<tr>
<th>Parameters name</th>
<th>AAMI standard</th>
<th>First RO output</th>
<th>p value</th>
<th>Second RO output (dialyzer input)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate (mg/l)</td>
<td>100</td>
<td>6.8±0.3</td>
<td>&lt;0.001</td>
<td>5.5±0.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nitrate (mg/l)</td>
<td>20</td>
<td>0.18±0.06</td>
<td>0.003</td>
<td>0.25±0.12</td>
<td>0.004</td>
</tr>
<tr>
<td>Fluoride (mg/l)</td>
<td>0.2</td>
<td>0</td>
<td>0.005</td>
<td>0</td>
<td>0.005</td>
</tr>
<tr>
<td>Chlorate (mg/l)</td>
<td>0.5</td>
<td>0</td>
<td>0.007</td>
<td>0</td>
<td>0.007</td>
</tr>
<tr>
<td>Calcium (mg/l)</td>
<td>2</td>
<td>2.6±0.82</td>
<td>0.35</td>
<td>1.9±0.73</td>
<td>0.39</td>
</tr>
<tr>
<td>Magnesium(mg/l)</td>
<td>4</td>
<td>0</td>
<td>&lt;0.001</td>
<td>0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sodium (mg/l)</td>
<td>70</td>
<td>2.15±0.46</td>
<td>&lt;0.001</td>
<td>4.41±0.46</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Potassium(mg/l)</td>
<td>8</td>
<td>3.1±0.1</td>
<td>0.006</td>
<td>4.7±0.1</td>
<td>0.007</td>
</tr>
<tr>
<td>HPC (CFU/ml)</td>
<td>200</td>
<td>8±2</td>
<td>&lt;0.001</td>
<td>6±1</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

that the evaluated parameters level in water entering dialysis devices is lower than AAMI standard in term of toxicity limit. For this reason, the entered water to dialysis devices has higher assurance. The results of present study are consistent with some studies and are different with the results of some study. Asadi et al. (2010) evaluated 45 dialysis devices input water samples in Qom hospital and showed that the average level of Ca, Mg, Na, K were lower than the AAMI standards (ASADI et al., 2012). Asadzadeh et al. (2013) showed that in 66 samples were taken from dialysis devices input water in Gonabad the amount of calcium was higher than the AAMI standard (Asadzadeh et al., 2014). The other study was done by Alizadeh et al. on 34 dialysis devices input water samples. They showed that there was no biological contaminant in input water, but Calcium concentration was higher than the AAMI standard.
(Alizadeh et al., 2013). In the present study, the level of calcium in dialyzer input water was higher than the standard limit. This can be prevented by proper operation of RO device like timely membrane exchange and periodic washing based on the manufacturer recommendation.

Baseri et al. (2011) showed that the evaluated average level of all physical and chemical parameters in Akhavan hospital (Kashan) was lower than the standard and none of the samples have biological contaminant (Baseri et al., 2013) (17). In a study of Kelin et al. in Central America on 51 input water of dialysis center, it had revealed that 35% and 19% of the dialysis devices input water samples considering usual biological and endotoxin quality, receptively (Klein et al., 1990). Mahlooji et al. in their study showed that the evaluated dialysis devices input water samples of hemodialysis ward in Taleghani hospital (Oromie, Iran) were not consistent with AAMI standard for their endotoxin quality (with 200 CFU/ml standard limit) This fact could be an important factor in increasing dialysis side effect. But in the present study, both biological and endotoxin quality were consistent with AAMI standard.

The most important reason for biological contamination of dialysis devices input waters could be related to the secondary contamination that occurred during storage and transmission water from RO devices to the dialysis device (Makhdoumi et al., 2006).

**Conclusion**

Based on the results it could be said that the proper performance of RO devices and secondary contamination prevention during purified water storage and transmission has been caused to proper chemical, microbial and endotoxin water quality according to AAMI standard in hemodialysis ward of Imam Reza hospital, Kermanshah, Iran. The short time use of dialysis devices (new systems) and also proper operation of the devices by operator in hemodialysis ward could be other reasons for suitable quality of dialysis devices input water. So, as a final point, it can be concluded that the proper operation of dialysis device, pretreatment system of input water (RO device), and secondary contamination control are very important for dialysis device water to be consistent with standard.

**Acknowledgment**

The authors of this article appreciated the Imam Reza hospital manager special the hemodialysis wards personnel for their cooperation in samples collection and also thanked the biological and chemical laboratory experts of health faculty of Kemanshah for their guidelines in doing the tests.

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