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Copper and Silver Water Treatment

Copper and Silver Ionisation and Dialysis Water Filtration System

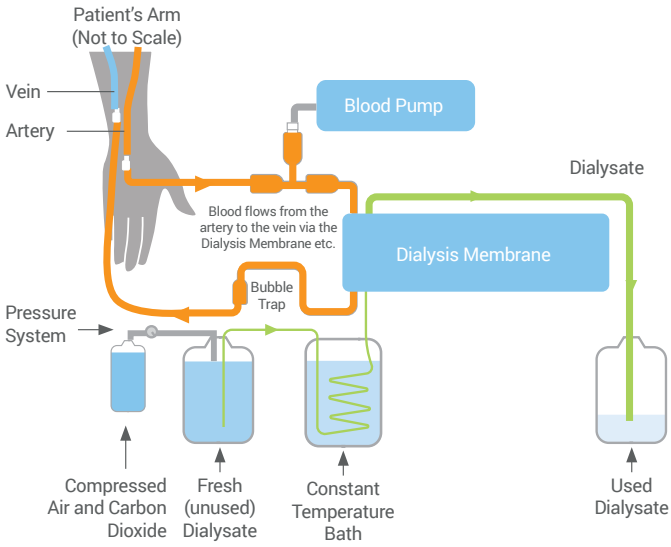
Dialysis water

Approximately 400 litres of water are used weekly for producing dialysis fluid. It is, therefore, important to know and monitor the chemical and microbiological purity of this water (Pontoriero et al 2003). Hospital dialysis units have to deliver high purity water which is free from contaminants and, therefore, metals and chemical compounds should be removed from it. To ensure the water is free from impurities standard drinking water undergoes additional treatments such as filtration and reverse osmosis.

What can contaminate dialysis units?

Water used for the preparation of dialysis fluid should ideally be ultrapure water or at least meet the minimum standard of purity given in Table 1 (Mactier 2007). The table includes contaminants that should always be included in routine testing as they occur in relatively high levels and are not restricted in drinking water (chlorine, calcium, magnesium), those for which drinking water limit is more than five times the recommended limit for water for dialysis, and all contaminants for which the drinking water limit is 2 to 5 times the recommended limit for dialysis. In water treated by reverse osmosis, these contaminants will only exceed the limits in table 1 if they occur at relatively high levels in the water supplied to the unit. These contaminants can be omitted from routine tests if data is available to show that the levels in the water supplied to the unit rarely exceed the limit in the table. These data should be obtained from the municipal water supplier or from tests on the raw water if it is obtained from a private source (Mactier 2007).

Table 1 is from the Renal Association's document "Clinical Practice Guidelines Module 2: Haemodialysis" and shows the list of possible contaminants and their maximum recommended concentration in water for dialysis. As shown in the table, contaminants include the chemical elements that are widely used in products and processes and thus can end up in water courses (e.g. aluminium, calcium, potassium, sodium, magnesium, chlorine, chloride, fluorine, fluoride, copper, cadmium, lead, mercury, silver, tin, zinc); chemical compounds (e.g. nitrate, ammonium, sulphate) as well as bacterial contaminants (e.g. bacteria, TVCs and endotoxins). Removal of these contaminants from water, therefore, has to be carried out to ensure that maximum concentrations of chemical and microbial contaminants allowed in dialysis water are not exceeded, and this is usually done by filtration (Figure 1). If the filtration equipment fails then contamination of the dialysis water and the patient's blood could occur.



Dialysis diagram (ivyrose.com)

Table 1: Maximum recommended concentrations for chemical and microbial contaminants in water for dialysis

Contaminant	Criteria for inclusion in routine tests	Maximum recommended concentration (mg/L = ppm)	Standards on which limit is based	Initial Test Frequency (if not omitted)
Aluminium	Mandatory	0.01	EP, AAMI, ISO	3 monthly
Calcium	Mandatory	2 (0/05 mmol/L	EP, AAMI, ISO	3 monthly
Total Chlorine	Mandatory	0.1	EP	Not less than weekly
Copper	Mandatory	0.1	AAMI, ISO	3 monthly
Fluoride	Mandatory	0.2	EP, AAMI, ISO	3 monthly
Magnesium	Mandatory	2 (0.08 mmol/L)	EP	3 monthly
Nitrate (as N)	Mandatory	2 (equates to 9 mg/LNo3)	AAMI, ISO	3 monthly
Potassium	Mandatory	2 (0.05 mmol/L)	EP	3 monthly
Sodium	Mandatory	50 (2.2. mmol/L)	EP	3 monthly
Bacteria (TVC)	Mandatory	100 cfu/ml	EP, ISO	Not less than monthly
Endotoxin	Mandatory	0.25 IU/ml	EP	Not less than monthly
Ammonium	Omit if evidence permits	0.2	EP	3 monthly
Arsenic	Omit if evidence permits	0.005	AAMI, ISO	3 monthly
Cadmium	Omit if evidence permits	0.001	AAMI, ISO	3 monthly
Chlorine	Omit if evidence permits	50	EP	3 monthly
Chromium	Omit if evidence permits	0.014	AAMI, ISO	3 monthly
Lead	Omit if evidence permits	0.005	AAMI, ISO	3 monthly
Mercury	Omit if evidence permits	0.0002	AAMI, ISO	3 monthly
Sulphate	Omit if evidence permits	50	EP	3 monthly
Barium	Include on indication only	0.1	AAMI, ISO	As indicated
Beryllium	Include on indication only	0.0004	AAMI	As indicated
Silver	Include on indication only	0.005	AAMI, ISO	As indicated
Tallium	Include on indication only	0.002	AAMI	As indicated
Tin	Include on indication only	0.1	ISO	As indicated
Zinc	Include on indication only	0.1	EP, AAMI, ISO	As indicated

Note: Antimony (AAMI limit 0.006 mg/L) and selenium (AAMI and ISO limit 0.09 mg/L) have been excluded from this table as the limit for drinking water in the UK is lower than the limit for water for dialysis.

Legionella in water systems

Legionella pneumophila is a disease-causing microorganism, which is ubiquitous in water systems and can infect people, being particularly dangerous for hospital patients that have a compromised immune system. L. pneumophila is well known for causing Legionellosis (Legionnaire's disease and Pontiac fever). Legionella can survive extreme water temperature ranges, 0°C to 63°C (Nguyen et al. 1991), with an optimum temperature growth range between 38°C and 46°C and multiples rapidly in untreated or ineffectively treated water systems. No doubt, Legionella has to be controlled in water systems, especially in hospitals to protect patients. Many control strategies exist, but where dialysis units are in place, the Legionella control system cannot interfere with or contaminate the dialysis system.

Which Legionella control method is less likely to contaminate Dialysis water units?

The dialysis filtration system can fail if using compounds like silver hydrogen peroxide as a biocide to control Legionella in the water system, as happened in Leicester General Hospital some years ago (Martin 2008). The filtration system was not able to cope with the high concentration of silver hydrogen peroxide in the water, resulting in contamination of the dialysis water. This would not have happened if the hospital was using pure Copper and Silver Ionisation for pathogens control in the water systems, i.e. the dialysis water filtration system would have been able to cope without any problems. This is because the levels of ions of copper and silver released into the water by the copper and silver ionisation system are extremely small (0.200-0.800 mg/L for copper and 0.020-0.080 mg/L for silver). Sometimes people get confused with these two systems and, therefore, we will take this opportunity to point out that there is a

huge difference between copper and silver ionisation and silver hydrogen peroxide – the two modalities are completely different. The concentrations of silver salts (not ions) used in silver hydrogen peroxide are between 8 to 12 mg/L (more than 400 times the level used in Cu-Ag ionisation).

Reverse osmosis is capable of excluding metal ions, aqueous salts and molecules from the treated water (Coulliette & Arduino 2013). Ultrafiltration and endotoxin-retentive filters can be included after the deioniser, immediately after the storage tank, and/or before delivery to the dialyser depending on the design of the system (Ward 2004) to remove bacteria and endotoxin by using a positively charged filter surface and size exclusion.

ProEconomy Ltd, who are the only providers of the Orca pure copper and silver ionisation system for pathogens control in water has carried out analysis to measure levels of copper and silver before and after dialysis water filtration equipments and the results are shown in Table 2, where it can be seen that the copper concentration before the RO unit was 0.246 mg/L and after the unit was <0.003 mg/L, showing almost complete removal to well below the recommended levels (0.1 mg/L). The silver concentration before the unit was 0.059 mg/L and after it was 0.0004 mg/L, which again shows almost complete removal to well below the allowed levels (0.005 mg/L) as shown in Table 1.

Table 2: Copper and Silver Before and After Dialysis Water Filtration

Sample Id	Copper (mg/l)	Silver (mg/L)
Maximum recommended concentration (Renal Association, AAMI-ISO)	0.1	0.005
Renal Dialysis Before osmosis	0.246	0.0593
Renal Dialysis After osmosis	<0.003	0.0004

References

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