In-line filtration retains particles produced during tubing spallation infused into the extracorporeal circuit during CRRT

UNIVERSITÀ DEGLI STUDI FIRENZE
DSS DIPARTIMENTO DI SCIENZE DELLA SALUTE

Giulia Cocci[1], Raffaella d'Errico[1], M.C. Ruffa[2], Gianluca Villa[3,4], Stefano Romagnoli[3,4]

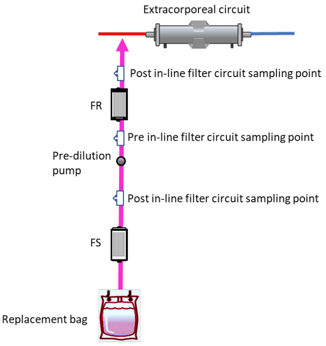
[1] School of Anesthesia and Critical Care, University of Florence, Florence, Italy
[2] Department of Applied Science and Technology, Polytechnic University of Turin, Turin, Italy
[3] Department of Health Science, University of Florence, Florence, Italy
[4] Department of Anesthesia and Critical Care, Azienda Ospedaliero-Universitaria Careggi, Florence, Italy

Membrane fouling has a direct effect on extracorporeal transmembrane clearance of water transmembrane removal during continuous renal replacement therapy (CRRT). Clogging is a possible cause of this phenomenon, and it may be due to the release of particles into the extracorporeal circuit. Indeed, peristaltic pumps are used to move fluids into the circuit. The tubing compression may release plastic particles into the extracorporeal circuit in a process called spallation. Spallation-induced particles are proportional to the pump speed and correlate with increased production of interleukin (IL-1) by macrophages, local and systemic endothelial activation and finally with patient's organ damage. The aim of the study is to verify the presence of particles into the extracorporeal circuit due to spallation and to evaluate the qualitative and quantitative effectiveness of in-line filtration for particles retention.

Methods

In vitro experiments simulating CVVH were performed at the ''Laboratory of Extracorporeal Blood Purification Therapy'' of the Department of Health Sciences, Section of Anaesthesiology, Intensive Care and Pain Medicine, University of Florence. Two in-line filters for particles retention were applied to the extracorporeal circuit in the replacement line (pre-hemodiafilter). The former, between the replacement bag and the replacement peristaltic pump (FS), to depurate the replacement solution from particles derived from the plastic bag. The latter, placed between the peristaltic pump and the hemodiafilter (FR), should theoretically retain particles produced by spallation. CVVH was performed for 5 hours in pre- and post-dilution. The effluent dose was set at 28 mL/kg/h for an ideal 70 kg patient with 30% hematocrit and net ultrafiltration was not applied. Fluid samples (5 mL) were taken over the 5-hour treatment period. Samples were collected at the CRRT initiation and interruption, before and after the in-line filters for particles retention.

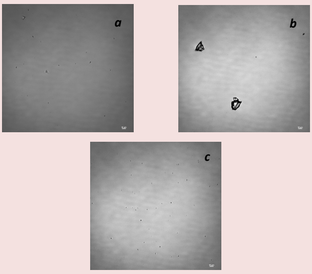
The samples obtained were analysed using different methods. Qualitative methods: optical microscope, field Emission Scanning Electron Microscope and Energy Dispersive X-Ray Spectroscopy (FESEM-EDX). Quantitative methods: weight of dry residue.



Results

Optical microscope

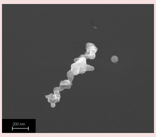
The optical microscope highlights the presence of particles in the replacement solution, their morphology and average diameter. It was noted that the number of particles detected decrease downstream of the in-line filter for particles retention compared to upstream due to the effect of in-line filtration.

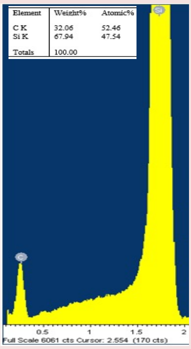


Light microscope images of the replacement line solution at the CRRT interruption, post in-line filter FS for particle retention (a), pre (b) and post (c) the in-line filter FR for particles retention.

FESEM-EDX

The FESEM-EDX method highlights the presence of micro-sized particles in the solutions . The most common microplastic particles, on the other hand, are composed of carbon and oxygen.

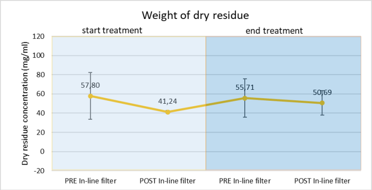




Example of micro-sized particles detected within the samples acquired at 50.00KX (above). The spectra detected by EDX show the chemical composition of the particles (C). The Si detected represents the wafer substrate (right).

Weight of dry residue

The dry residue method allows a quantitative analysis of the concentration of particles in samples. Using the data of the empty weight and the dry weight of the tubes, in which the collected samples were placed, the dry residue weight of the solution was calculated. The obtained results, in terms of mean and standard deviation of the two experimental sets, show that the amount of particles was reduced in the samples collected after the in-line filter for particles retention compared to the samples obtained before the in-line filter. This highlights, once again, the effectiveness of in-line filtration.



Mean and standard deviation of dry residue concentrations in the two experimental sets pre and post in-line filter (FR) at CRRT initiation and interruption.

Conclusion

As demonstrated in this study, the materials of which the CRRT circuits are made and the compressive movement of the pumps can release microplastic particles. Their morphology and concentration can be assessed using the optical microscope, the FESEM-EDX method and the weight of dry residue method. According to literature studies on animal models, some types can have harmful effects and be correlated with increased production of interleukin (IL-1) by macrophages, local and systemic endothelial activation and finally with patient's organ damage. The in-line filtration processes decrease the presence of these particles and it has been shown that it also reduces the incidence of phlebitis and catheter infections.

40TH VICENZA COURSE on AKI&CRRT
SPECIAL EDITION
June 14-16, 2022