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Hyper-pressurization of the dialysate fluid as a temporary solution to the failure of the dialysate flow pump in volumetric hemodiafiltration machines

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Abstract

Introduction: The decrease in the pressure of the dialyzed fluid is associated with the loss of power of the motors that pressurize the system in a volumetric hemodiafiltration machine. We present a way to maintain the operability of hemodiafiltration treatment.

Technical case: The monitor is an NCU-18-Nipro hemodiafiltration machine with 14426 hours of use. During the startup test, the system reported an error in the flow control of ultrafilter one due to a loss of power from pump 1 of the dialysate flow; the position of the head from pump P2 to pump P1 was changed. , and system pressurization calibration. The problem was temporarily resolved for three months. After this period, the error occurred again; it was decided to hyper-pressurize the system, with which the machine entered the entire operation for three additional months. Once the new head of the CFL1 pump has arrived, it is verified that the base of the pump has also lost strength; the change of the base is planned. The machine is kept operational by hyper-pressurizing the system, and with hyper-pressurizing, the reducing valve at the point of entry of water from the ring; the machine operates with a maximum of 22 liters of replacement, this maneuver gave enough time to import the base of the pump.

Conclusion: The hypertension of the dialysate fluid pressurization system is a compensatory measure for the failure of pressurization pumps, which gives a period of 3 to 6 additional months for the change of spare parts; however, this procedure causes a charge to the motor of the pumps that determine a change of the same ones at the end of the second period.

Keywords:

MESH: Hemodiafiltration; Renal Dialysis; Kidneys, Artificial; Water Pressure Meters; Pressure Reducing Valves. **Author Words**: NCU-18, E055, E056, Water supply error, FS2 sensor alarm.

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The pressure of the dialysate fluid is a conditional factor for the operation of the solenoid valve system of the hemodiafiltration equipment. The dialysate system pressure begins with the inflow of ultrapure water through the distribution system ring, usually between 30 to 50 pounds per square inch (psi), equivalent to 1550 to 2585 mmHg. The job of a first pressure-reducing valve with a screw and seed system is to reduce the pressure to an input value of 250 to 300 mmHg (on average 275 mmHg). Next, an electronic card with two potentiometers regulates the millimeter precision of the closed system first without flow (zero value). With a pressure of 300 mmHg, the closed system is regulated at 275 mmHg. A verification system with 1 flow sensor before the dialysate pressure card (PD) gives a flow alarm, which verifies the operation. The system is pressurized by the action of electromagnetic pumps P1 and P2 with the head of blades of millimeter gear [1].

The operation of the hemodiafiltration system with high flow in the dialysate fluid (600 to 700 ml/min), with high substitution fluid replacement (>24 liters in postdilution mode or >38 liters in predilution mode), mainly causes the blades of the P2 pump to decrease their mass by friction (Figure 1) in a period of 24 to 30 months of continuous operation (3 shifts per day, six days per week). This wear of the blades of pump head P2 causes a drop in system pressure, causing a series of predictable, sequential errors (table 1).

Table 1. Errors associated with the depressurization of the dialysate fluid system in Nipro NCU-18 machines

mistake _	Description
E055 and E056 *	Water supply error
E025	FS2 sensor alarm
E060	Dialysate Pressure Gauge Check Error
E101	Supply conductivity alarm
CFL1	Ultrafilter 1 flow control error
CFL2	Ultrafilter 2 flow control error
E163	Reducing valve error

The optimal option is to change the blades of the head. In principle, the system can compensate by recalibrating the dialysate fluid pressure and the water inlet pressure again; however, this causes a more significant workforce of the electromagnetic pumps P1 and P2, which continuously continue to lose power, and the problems continue to increase. A technical case of partial resolution is presented below, with the requirement to continue service of the hemodiafiltration monitor so as not to affect patient care. At the same time, imported spare parts arrive at the hemodialysis center.

Technical case

Scenery

The technical case study was carried out in the maintenance department of the Pafram Clinic hemodiafiltration unit in Santa Marianita-Sucúa, Morona Santiago-Ecuador, from April 1, 2022, to November 18, 2022.

Display

The monitor is an NCU-18 volumetric hemodiafiltration machine with 14426 hours of use and high performance.

Exchange of pump head from P2 to P1

During the initial tests in each treatment, the system continuously reports CFL1 failure. It is observed that the required test for the automatic calibration of the test requires that the pump in the first phase generate a negative pressure of -480 mmHg to pass the test; the pump does not pass a value of -300 mmHg, for which reason we proceeded to the change of the position of the head of the P2 pump to the P1 pump and calibration of the pressurization of the system, with which the problem was temporarily resolved for approximately three months. After this period, the CFL1 failure problem occurs again in the startup test.

Hyperpressurization of dialyzate fluid

To maintain patient care, the system is pressurized. The CFL1 filter was replaced. The dialysate pressure was calibrated at 340 mmHg, and the card pressure in room air was calibrated for baseline (usually at zero) at 10 mmHg and the high value at 460 mmHg, with 100 mmHg more than the usual value. With these changes, the machine started operating, the postdilution replacement fluid values remained at 25 liters, and the dialyzate fluid was 500 ml/min (Qd). Only when requiring predilution substitution when there was a need for precoagulation of the system did the machine report "dialysate fluid error," which was corrected by lowering the usual programmed volume from 38 liters to 30 liters and sometimes decreasing the Qd to 400 ml/min. The spare parts had been requested; this compensation gave the machine utility for an additional three months.

P1 pump head change

Once the new head of the CFL1 pump arrived, the change was made; however, it was not enough to fix the error, and with the normal pressurization of 275 mmHg, error E055 and error E025 (water supply and pump alarm) are presented. FS2 sensor). In a manual verification in the valve test screen, it is verified that when turning on the P1 pump, the base of the head does not have enough power to move the pump head. The importation of a complete pump (with base included) was needed, and it is planned that the machine will be out of service during the

importation. Due to institutional necessity, it is requested to enable the machine again until a definitive solution is reached. For this reason, a new hyperpressurization of the dialysate fluid system is proposed, now with additional pressure on the reducing valve at the point of entry of water from the ring, in a pleasing way to avoid the error E025 Flow sensor 2 (FS2) alarm and in a way that is not so adjusted to avoid the error E163 of reducing valve failure, with the trial-error system with valve turns of 30 by 30° (equivalent to 10 minutes on a clockwise scale).

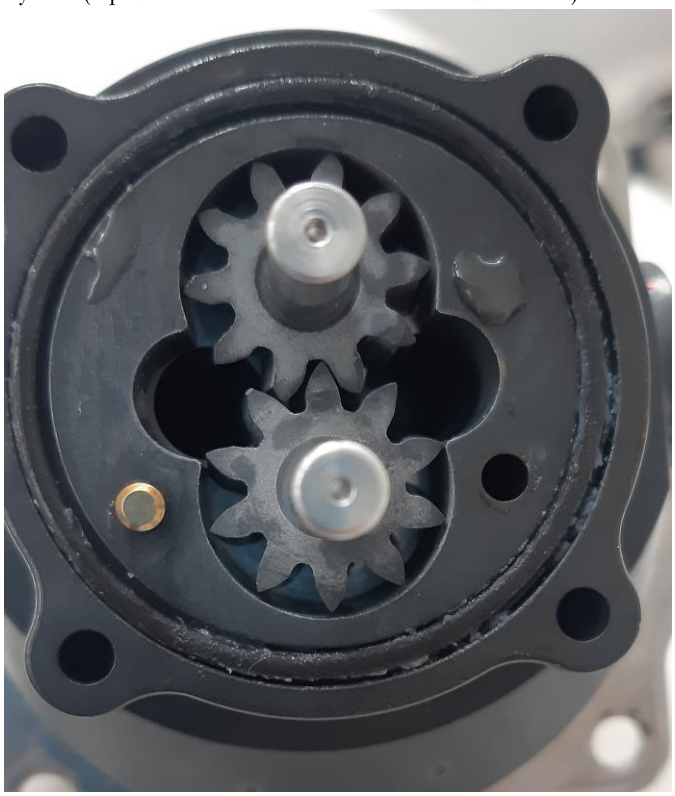

Figure 1 Gear vanes of the dialysate fluid pressure motor. The friction area causes an undercut at the base of the upper blade, increasing the void space between the blades, which should be nonexistent.

Current evolution

The machine was put into service again, with an adjustment during the beginning of the treatment to reduce the pressure of the dialysate fluid from 640 mmHg to 300 mmHg. The treatments were performed, giving a control error of the dialysate fluid, so the treatments were prescribed with a 22-liter replacement fluid, removing the error. The Qd was 500 ml/min. At the time of treatment, a dialysate fluid control error was reported, so the dialysate flow was lowered to 400 ml/min and continued in service. If patients require predilution hemodiafiltration, the dialysate flow is reprogrammed to 400 ml/min with a maximum replacement volume of 28 liters.

Discussion

Ecuadorian regulations give a half-life of hemodialysis equipment of 8 years [2]; on the other hand, the use of a high-volume, high-replacement hemodiafiltration machine causes, on average, part changes to be required from the 2nd year, leaving a 6-year difference that must be corrected by arrangement, adaptation, and import of parts. Additionally, an intradialytic hemodialysis machine technician is essential from the second year onward.

In the specific technical case that we present, we demonstrate that raising the pressure of the dialyzed fluid in a pressurized system where there has been wear on the blades of the pressurization pumps partially compensates for the errors for a period of 3 to 6 months, enough time to plan a pump head change. However, maintaining this compensation over time for more than three months causes an overload of work to the motor, which reduces power and requires a total change of the pump, as occurred in the present case. Additionally, this required a constant technician during the treatments. Preventive maintenance would lead to the change of motor blades from the second year of service of the HDF machine.

In a review of publications, this is the first article that addresses this subject. To the best of our knowledge, future publications should address the implications of hyperpressurization.

Conclusions

The hypertension of the dialysate fluid pressurization system is a compensatory measure for the failure of the pressurization pumps, which gives a period of 3 to 6 additional months for the replacement of spare parts; however, this procedure causes a load on the motor of the pumps that determines a change in them at the end of the second period of dialysate hypertension.

Abbreviations

Qd: Dialysate flow.
FS: flow sensor.
PS: Dialysate pressure control card.
PR: Reducing valve.

Supplementary information

Supplementary materials have not been declared.

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Does not apply.

Author contributions

Franklin Mora Bravo: conceptualization, data curation, formal analysis, research, methodology, resources, and writing – original draft.
Pamela Morales Torres: conceptualization, acquisition of funds, project administration, software, supervision, validation, visualization, and writing: review and edition.
Juan Guacollantes: Methodology, Research, Methodology, Resources, validation, supervision, writing: Review and editing.
Juan Carlos Calva: Methodology, validation, supervision, writing: Review and editing.
Leonardo Macías: Methodology, Research, Methodology, Resources, validation, supervision, writing: Review and edition.
All authors read and approved the final version of the manuscript.

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The data sets generated and analyzed during the current study are not publicly available due to participant confidentiality but are available from the corresponding author upon reasonable scholarly request.

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Ethics committee approval and consent to participate

This does not apply to

Consent for publication

It does not apply when images or photographs of the physical examination or X-rays/CT/MRI of patients are not published.

Conflicts of interest

The authors report having no conflicts of interest.

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