Module 2: Aquarius Training
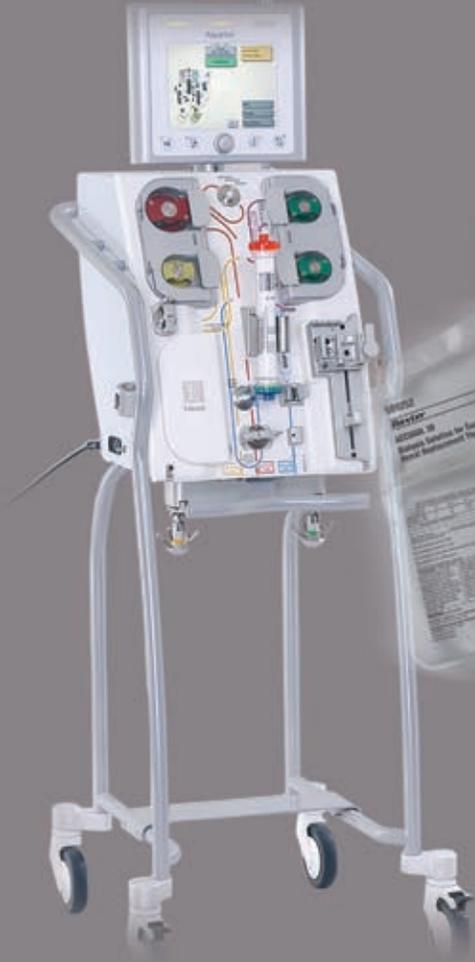
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AQUARIUS TRAINING

TABLE OF CONTENTS

These materials were created by Edwards Lifesciences Corporation as part of the Critical Care Nephrology Alliance. Seeking to provide CRRT professionals with the highest caliber of multidisciplinary expertise, products and services, the Alliance brings together the unique strengths of Baxter Healthcare Corporation, an expert in renal therapies, and Edwards, a leader in critical care.

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THE AQUARIUS SYSTEM

The material presented in this program is based on the Aquarius Operator's Manual, Platinum Software version 6 US and the Aquarius v. 6 screens. The Operator's Manual and the screens provide the instructions necessary for the proper operation of the Aquarius System. This training program is designed to complement the Aquarius Operator's Manual and screens. It is not intended as a replacement. Please refer to the Operator's Manual and the screens for more detail.

The Aquarius System is indicated for continuous solute and/or fluid removal in patients with acute renal failure or fluid overload. It may also be used in Therapeutic Plasma Exchange (TPE) therapies.

LEARNING OBJECTIVES

- Understand the set-up, priming and operation of the Aquarius Hemofiltration system

- Understand pressure monitoring and alarm troubleshooting

- Complete the return demonstration portion of this training program

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Lesson 1: Introduction to Aquarius Platinum
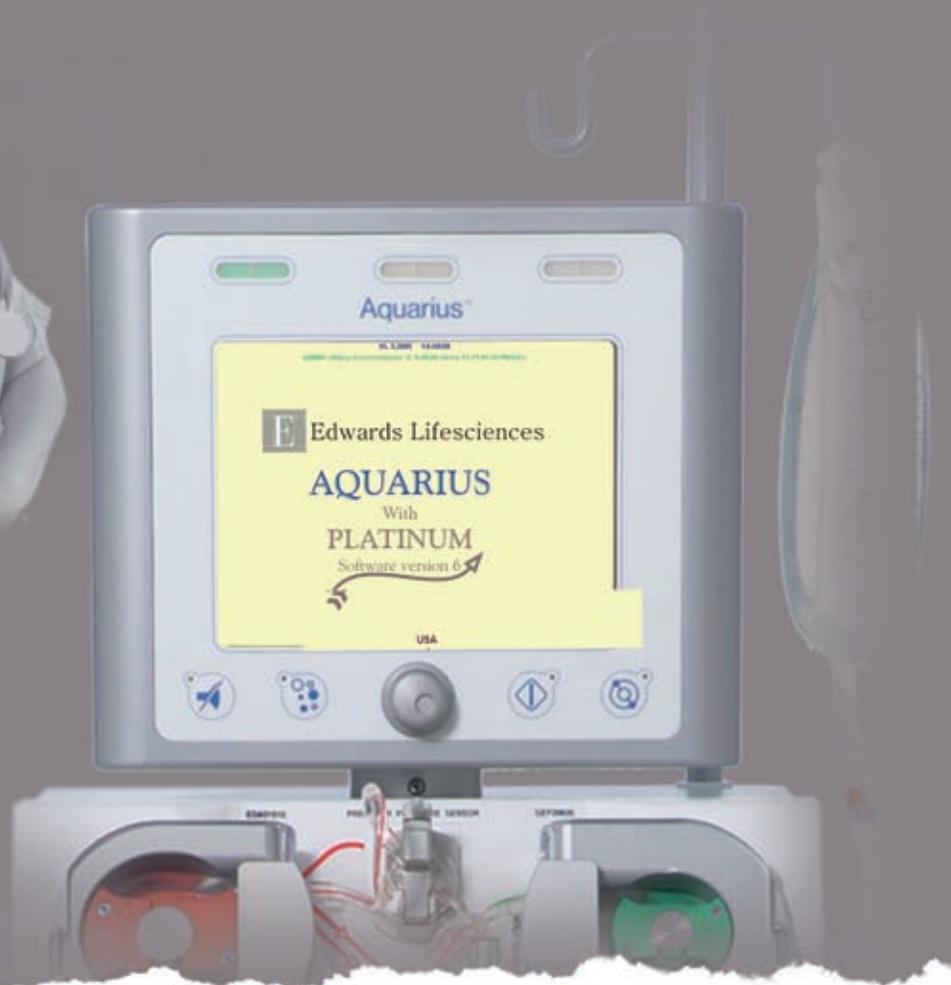
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AQUARIUS PLATINUM DESIGN CONCEPTS

- Patient safety
- Innovation
- Flexibility
- Ease of use
- Consistent messaging
- Upgradable as new needs/features arise

INTERACTING WITH AQUARIUS PLATINUM

The operator interfaces with Aquarius by turning and pushing the Main Selector button. This button is a rotary switch located below the display screen. It is used to select and confirm different functions and to modify treatment parameters.

Main Selector button

USING THE SELECTOR BUTTON:

Turn: to highlight the parameter
**Push once**: to select the parameter
Turn right: to ⬆
**Turn left**: to ⬇
Push once: to confirm new values

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NAVIGATING BETWEEN SCREENS

The operator moves between screens by selecting a parameter and confirming the choice: 'Are you sure messages' indicate that the operator will need to confirm this choice before moving forward. The default choice is 'No.'

Next	Moves to the next screen
Previous	Moves back to previous screen
Yes	Confirms the selected choice
No	Cancels the selected choice and moves back to previous screen

'Help' screens will provide detailed information about individual screens and allow direct access to 'History'

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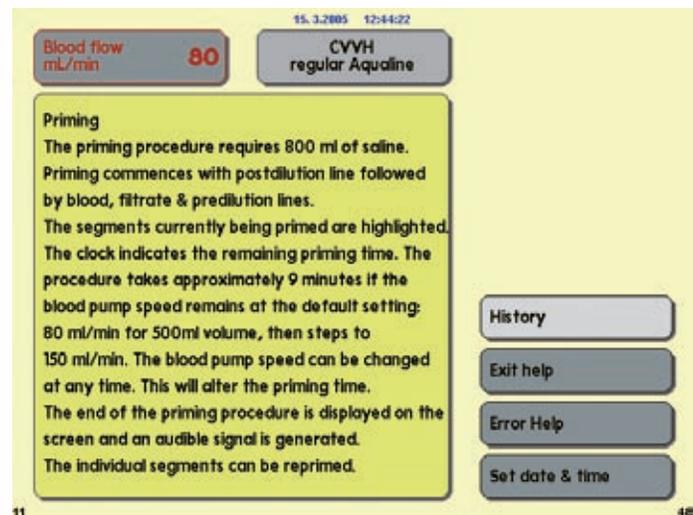
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CONSISTENT MESSAGING

Aquarius uses clear and consistent messaging, delivered in yellow or red message boxes, to inform and guide the operator through the screens. Example:

> Messages in a yellow box may describe a set up instruction, a parameter that is being programmed or an alarm that reminds the user that something needs to be done.

> Messages in a red background describe the alarm condition that is currently underway and needs the immediate attention of the user.

KEY FUNCTIONS OF THE AQUARIUS INTERFACE

Mute key

Blood Pump key

Clamp key   Main Selector button   Balance Start/Stop key

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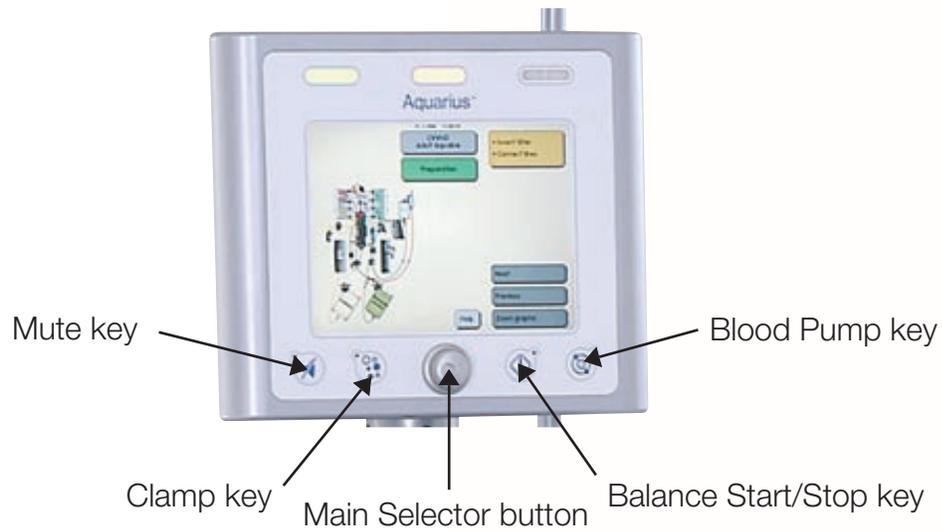
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INDIVIDUAL FUNCTION KEYS

The individual function keys and their displayed functions are explained below.

1. <u>Operation status display</u>

Three status lights indicate the different operation modes.

    A. An illuminated red status light indicates:

        ⚠ Warning! Alarm or system error.

    B. An illuminated green and yellow flashing status light indicates:

        ❗ Caution! Heater self test is running. Priming mode is not accessible.

    C. An illuminated green and yellow status light indicates:

        ❗ Caution! Treatment time has run down or Treatment was stopped.

        ❗ Caution! Bag change required.

        ❗ Caution! Anticoagulant syringe is empty.

        ❗ Caution! Aquarius is in Preparation or Recirculation or Connection mode.

    D. An illuminated green status light indicates:

        Treatment is running. No alarms are active.

    E. All three status lights illuminating one after the other indicate:

        Machine is performing system test.

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2. Mute function key

Pressing the Mute key enables the operator to silence the alarm signal for a period of two minutes. The LED integrated into the key flashes. If the cause of the alarm cannot be removed within the given period, the audible alarm is reactivated. If another alarm occurs during this period, the audible alarm is generated at once.

3. Clamp function key

Pressing the Clamp key opens the return line clamp during air alarm to allow removal of air bubbles from within the tubing set. The LED integrated into the key flashes. When the air is removed, treatment may be resumed by pressing the Blood Pump key. The return line clamp is automatically reactivated after one minute.

4. Main Selector button

The main selector button is a multi-function rotary button. These functions include:

a) Selecting function windows by turning the selector button
b) Confirming selected functions by pressing the selector button
c) Selecting input parameters by turning the selector button
d) Opening the input window for the selected parameter by pressing the selector button
e) Raising the parameter input for the selected parameter by turning the selector button to the right
f) Lowering the parameter input for the selected parameter by turning the selector button to the left
g) Confirming the entered parameter by pressing the selector button. The modified parameter is displayed on the screen

Notes:

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5. Balance Start/Stop function key

Pressing the Balance Start/Stop key stops the filtrate and substitution/dialysate pumps. This can be used to temporarily stop treatment, for example, to exchange bags. If an alarm occurs in the filtrate and/or the substitution/dialysate circuits, the pumps stop and the LED integrated into the key starts flashing. After correcting the cause of the alarm the pumps may be restarted by pressing the Balance Start/Stop key.

Balance Start/Stop key is also called Start Treatment key.

6. Blood Pump function key

Pressing the Blood Pump key starts or stops the flow of blood through the blood circuit. If an alarm occurs in the blood circuit, all pumps stop and the LED integrated in the blood pump key starts flashing. After correcting the cause of the alarm the system is restarted by pressing the Blood Pump key again. Filtrate pump, pre-dilution and post-dilution pumps start with delay in relation to the blood pump.

The Blood Pump key is also used to immediately stop all pumps in case of an unpredictable occurrence.

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Lesson 2: Preparing Aquarius

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POWER SUPPLY

Aquarius has two power supply switches.
The Main switch, on the left side of the machine should be set to position 1, the ON/OFF soft key switch is on the right side of the monitor display screen.

Main Switch   ON/OFF soft key

SYSTEM TEST

The system test takes approximately four minutes. When it is finished, an audible alarm is generated and the green and yellow status lights are illuminated. The pumps stop in the correct position for the tubing set to be installed. The operator can now proceed to set up.

! CAUTION: The Aquarius system test must be performed before tubing, bags, pressure sensors and solutions are placed on the machine. The pump doors must be closed.

15. 3.2005   14:46:04

**System test
running**

Master: 6.00.00
Video: V 6.00.00

Text Version 6.00.00
errtxt 6.00.0
modetxt 6.00.00

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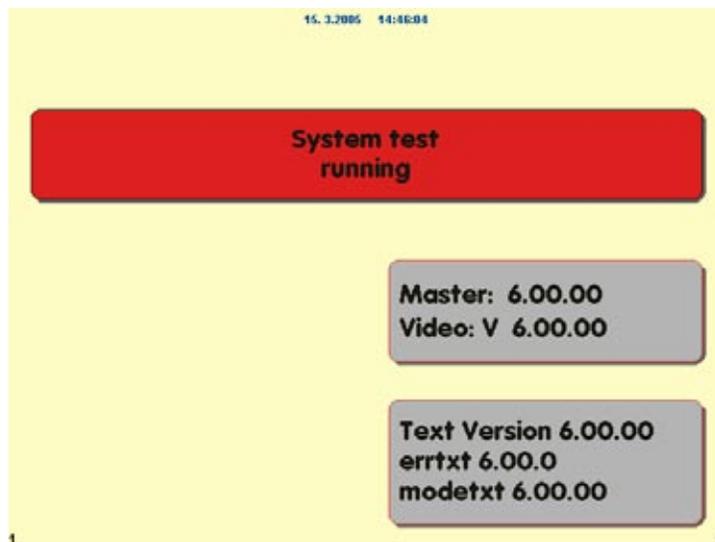
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SETTING UP AQUARIUS

1. Select the therapy to be used and confirm

- SCUF
- CVVH
- CVVHD
- CVVHDF
- Therapeutic plasma exchange (TPE)
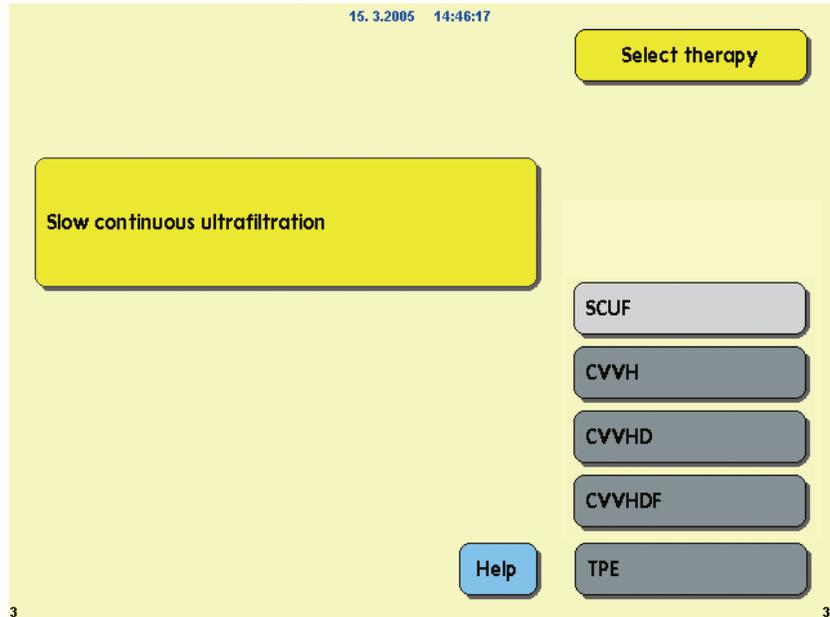
2. Select the type of Aqualine tubing set to be used and confirm

- Aqualine tubing set for regular treatment
    - Blood flow rates from 30-450 mL/min
    - Extracorporeal volume 100 mL
- Aqualine S tubing set for low blood flow treatment
    - Blood flow rates from 10-200 mL/min
   - Extracorporeal volume 61 mL

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3. Place selected Aqualine on Aquarius

Follow the detailed instructions listed below to place the lines and filter on the machine

ℹ️ NOTE: Alternatively, step-by-step, on-screen instructions for the placement of the lines and filters can be accessed in the Zoom graphic screens of Aquarius
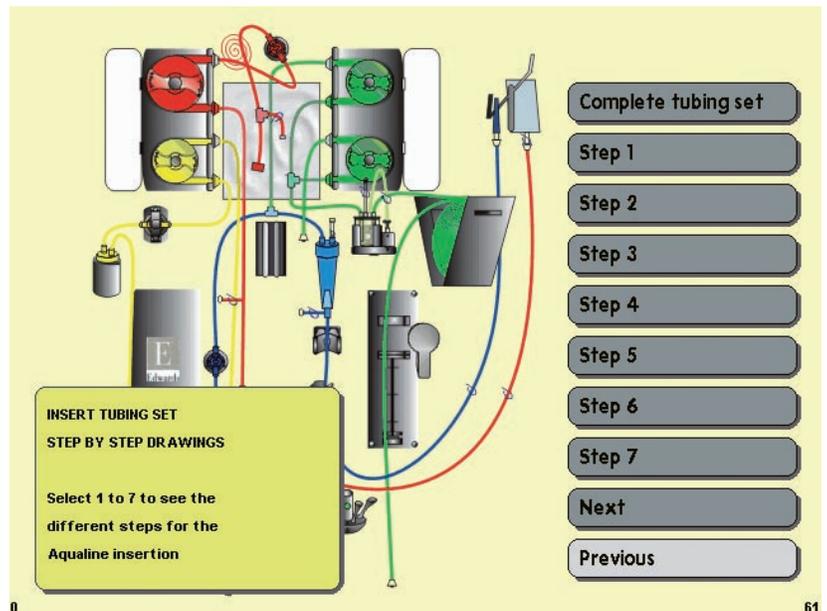
A. Place colored pump indicators in pumps. The colored pump holder segments are always at the bottom of the pumps

Blood pump (red): top left pump

Filtrate pump (yellow): bottom left pump

Post-dilution pump (green): top right pump

Pre-dilution/dialysate pump (green): bottom right pump

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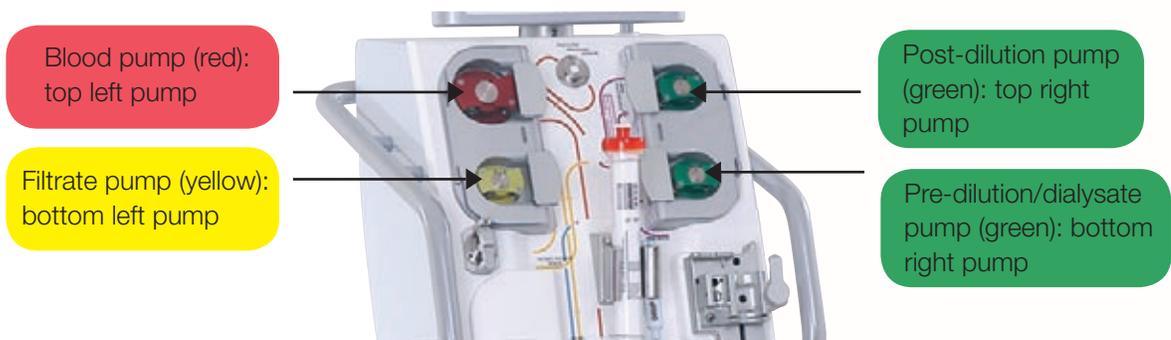
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B. Place automatic degassing chamber (ADU) in holder under green pumps. Ensure that the shortest line with the clamp is towards the back and the chamber cover is closed securely around the tubing

Chamber cover closed (B)

Line attached to ADU sensor (C)
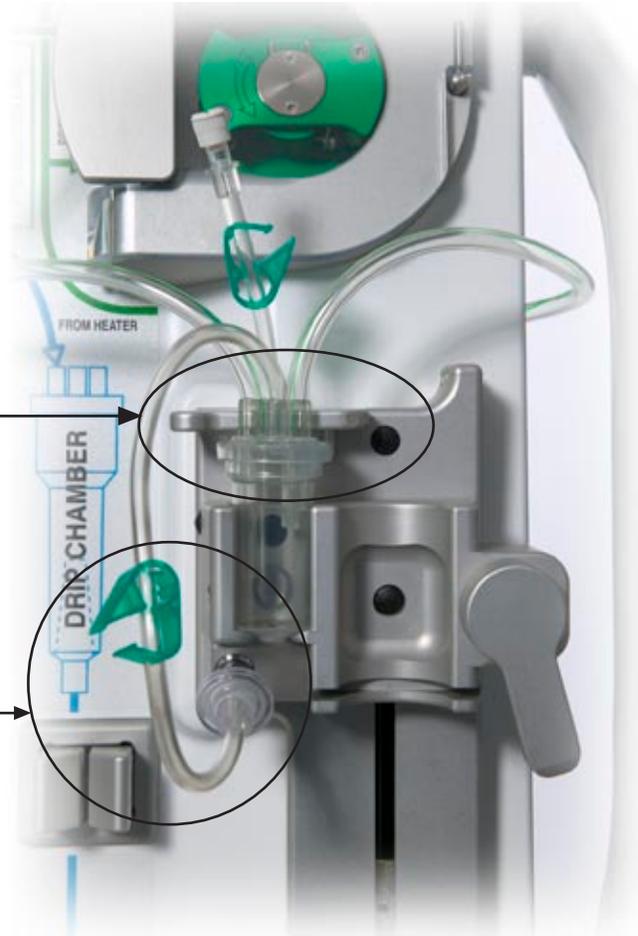
C. Attach the line with the luer lock, hydrophobic filter to the ADU sensor. The clamp should remain open

Notes:

D. Insert heater coil into heater on the right side of Aquarius (above the green scale) and close door

E. Locate the return line chamber (also referred to as the 'drip chamber') on the Aqualine, then insert the line underneath it through air detector channel and line clamp. Push and lock the air detector

Return line chamber

Air detector

Return line clamp

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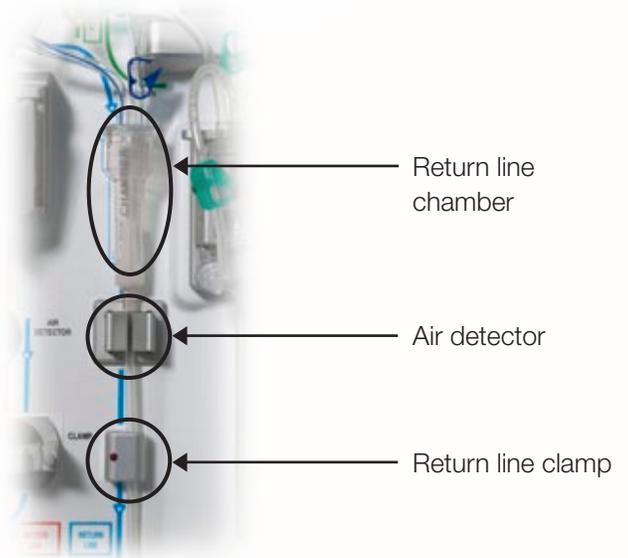
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F. Attach the pressure domes to the four pressure sensors (Prefilter, Filtrate, Return, Access) and close clamps

Prefilter

Filtrate

Return

Access
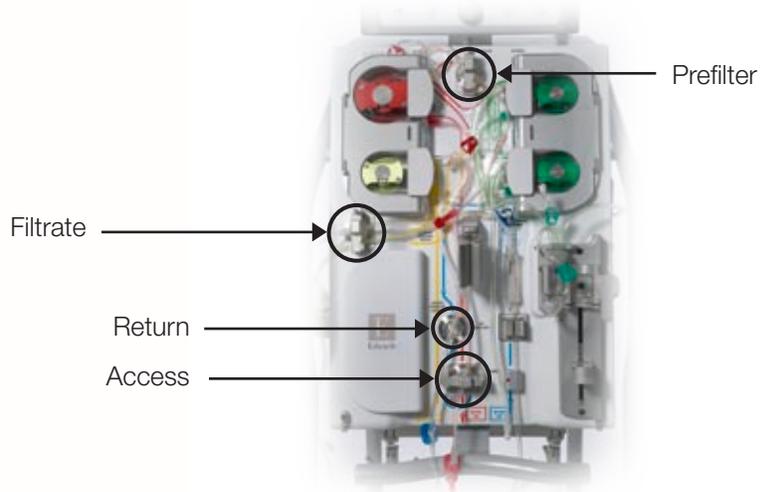
G. Insert blood leak chamber into the blood leak detector on the left side of Aquarius (above the yellow scale)

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H. Place prescribed hemofilter in filter holder and attach the red hemofilter connector to the red top of the hemofilter and the blue hemofilter connector to the blue bottom of the hemofilter

I. Attach filtrate line (short line from the blood leak detector) to the clear luer lock filtrate port on the top side of the hemofilter


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J.   Attach free line (located on the Aqualine as it exits the pre-dilution/dialysate pump)

ⓘ NOTE: The line exiting the pre-dilution pump (bottom green pump) is called the <u>free line</u>. The free line connection point determines what the therapy will be
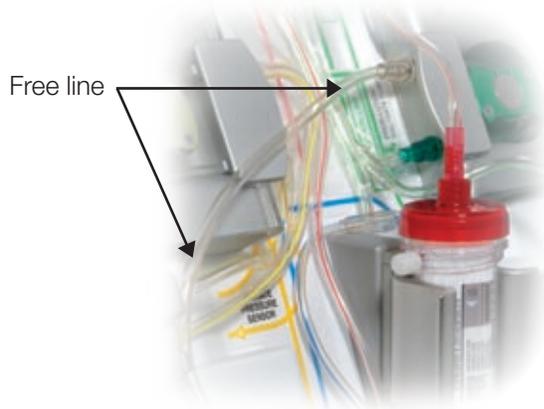
Free line

- CVVH:
  attach free line to the port located above the red end of the hemofilter

- SCUF, CVVHD or CVVHDF:
  attach free line to the dialysate port on the bottom side of the hemofilter

Free line connection

Free line connection

Notes: _____

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K. Hang empty prime collection bag on the IV pole located on the right topside of the Aquarius

L. Connect the red end of the Aqualine to the prime collection bag

M. Hang a one-liter bag of priming solution on the IV pole (usually heparinized normal saline) Insert the spiked Y-connector provided with the Aqualine into the priming solution bag

N. Remove the blue spiked end from the bloodline and connect it to one luer lock port of the Y-connector. (If you are not using a Y-connector, connect the blue spiked end of the bloodline to the priming solution.)

   ⓘ NOTE: Aquarius primes with a reverse flow through the blood circuit

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O. Hang empty filtrate bag(s) on yellow filtrate scale and connect the filtrate line (long line out of blood leak detector) to the bag(s)

ℹ️ NOTE: Ensure that an equal number of bags is used on the substitution/dialysate scale and the filtrate scale. Use empty 5-liter bags on the filtrate scale. For example, if TWO 2.5-liter bags are used on the substitution/dialysate scale, use TWO 5-liter empty bags on the filtrate scale

P. Hang prepared solution (substitution/dialysate) on green substitution scale and connect the substitution/dialysate line

ℹ️ NOTE: Aquarius uses a single solution source that is split by the machine and delivered as both dialysate and substitution solution, depending upon the therapy chosen. Up to four bags of solution may be used at one time. If using more than one bag, a multiport manifold will be required. To ensure proper, simultaneous emptying of multiple bags, all clamps must be open.

**Notes:** _____

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4. Prepare anticoagulant syringe

A. Aquarius may use a 50 mL or 60 mL syringe filled to a maximum of 50 mL. Only use the heparin syringe type that the Aquarius System has been calibrated to use (for example, a BD 50 cc syringe). The Aquarius System must be calibrated for the particular type of syringe you are using by a certified technician. A list of approved syringes is available in section 6.5 of Aquarius Operator's Manual. The syringe size that should be used is shown at the right of the 'Prepare syringe' screen
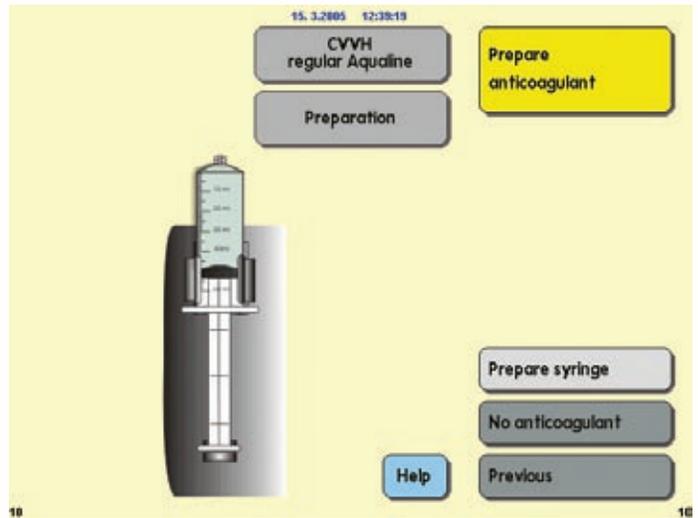
⚠ WARNING: Clamp anticoagulant line if no anticoagulant is used!

B. Select the volume in the syringe and confirm. Wait until the syringe driver moves to the correct position

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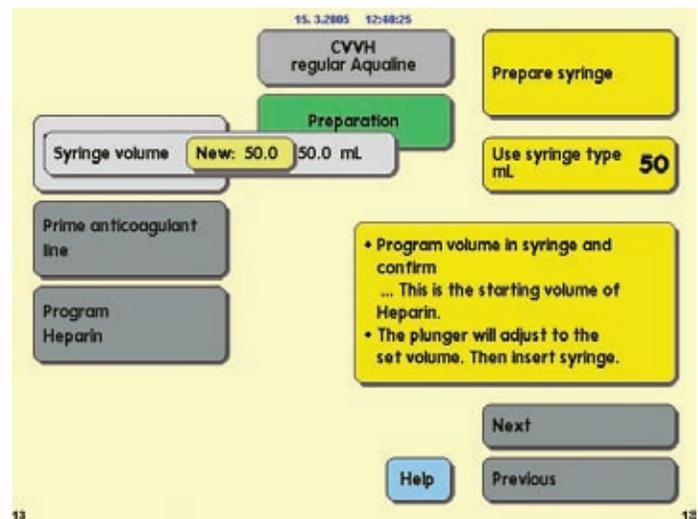
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C. Attach syringe to the anticoagulant
    line on the tubing set

Syringe attached ——————
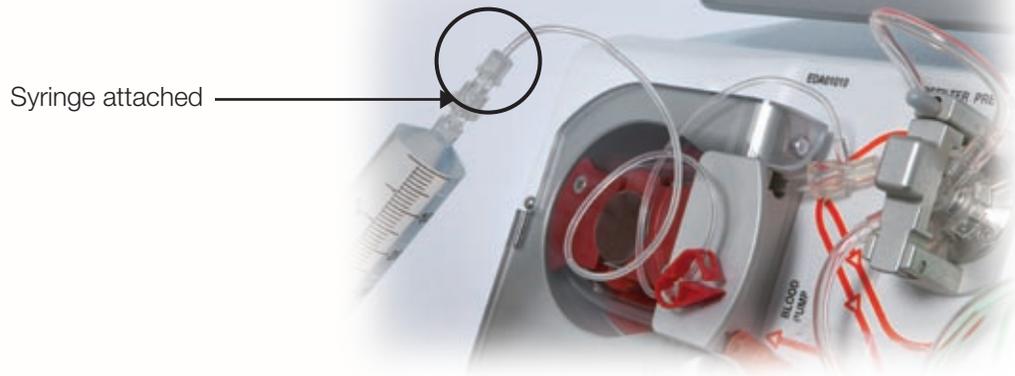
D   Install syringe into pump

Syringe in pump
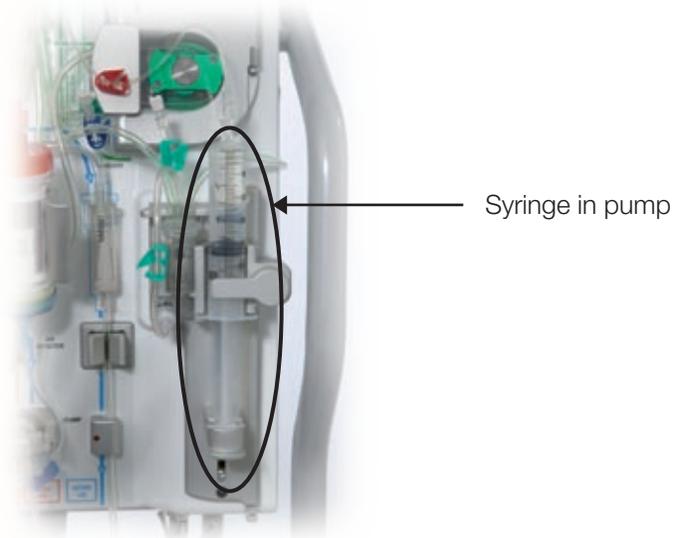
E. Prime anticoagulant line by selecting and confirming 'Prime anticoagulant line'. Each press of
    the selector button delivers one mL

F. Program heparin infusion rate   **Program Heparin**

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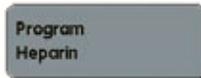
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PRIMING AQUARIUS

1. Select 'Next' to go to Priming

A. Check all lines for proper connection and open all clamps

⚠ WARNING: When 'No anticoagulant' is selected, the clamp on the anticoagulant line MUST remain closed!

B. Confirm that the correct solutions are used

⚠ WARNING: The solutions used for CRRT with Aquarius are prescription fluids. To ensure patient safety, please check that the prescribed solutions have been selected and properly prepared

2. Select 'Start priming' `Start priming`

A. The priming procedure requires about 800 mL of saline and takes approx. 9 min (Aquarius displays the message 'Priming. Please wait' and the clock counts down to zero)

B. The pre- and post-dilution lines are primed with fluid from the substitution/dialysate bag(s). The blood circuit and the filtrate lines are primed with fluid from the priming solution bag (usually heparinized normal saline)

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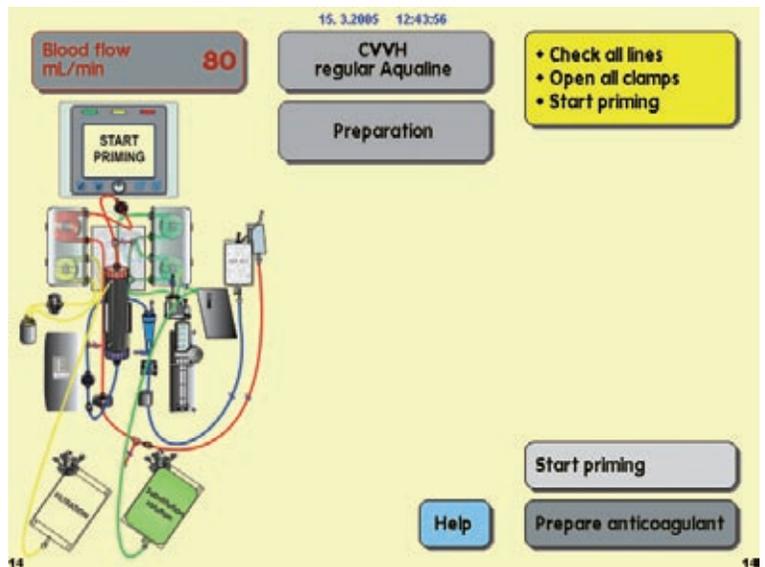
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C. Lines being primed are highlighted and Access, Return and TMP pressures are displayed

D. Priming starts at 80 mL/min for the first 6 minutes (approximately 500 mL) then increases to 150 mL/min

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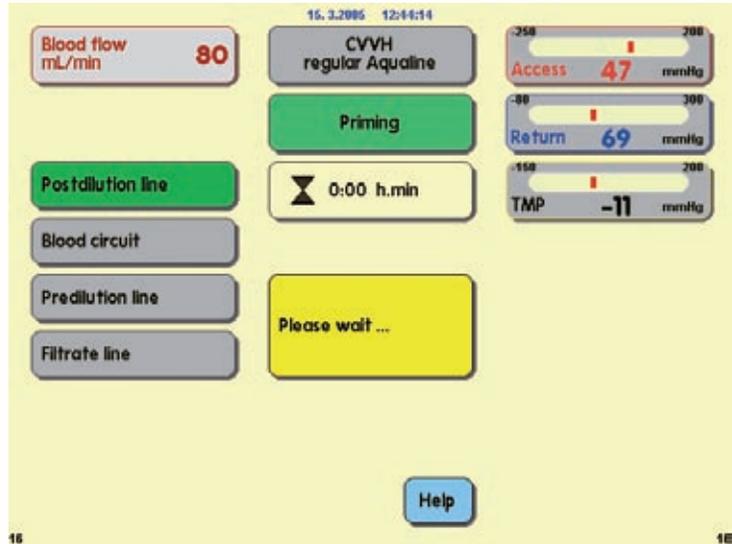
E. When priming is completed, you will hear an alarm and see the message 'Priming completed'

F. If needed, options are available to reprime parts, or all of the circuit

G. If the priming procedure is satisfactory, select 'Next' and confirm

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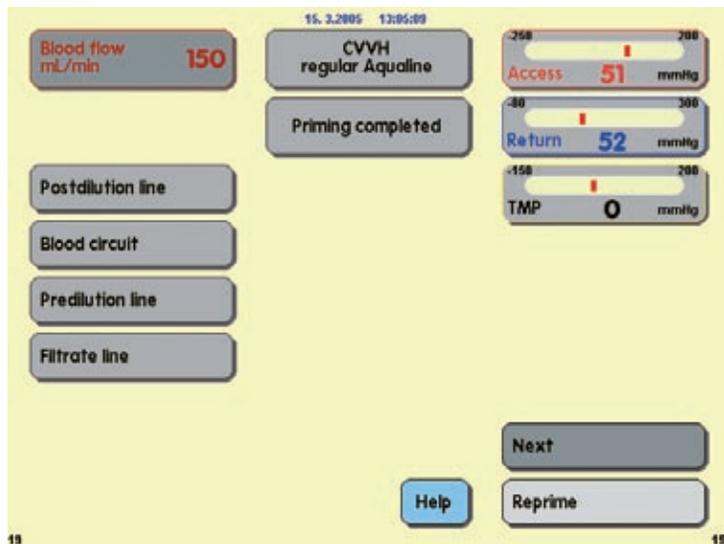
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CLAMP & PRESSURE TEST

- The 'Clamp & pressure test' checks the clamp, the air detector, and the access, return and pre-filter pressures
- It MUST be done before you can proceed to connection mode. Connect access and return lines to a single bag of normal saline using the Y-connector provided as part of the Aqualine, or any other appropriate connector
- The test takes just a few moments. If the test fails, follow the instructions displayed on the screen to determine the point of failure. Check connections and select 'Retest'
- When 'Clamp & pressure test' is completed, Aquarius switches to 'Start connection mode'
- Select 'Go to recirculation'
- Aquarius switches to Recirculation mode
- Press the Blood Pump key to start the flow of saline within the tubing set. You are now recirculating saline inside the circuit

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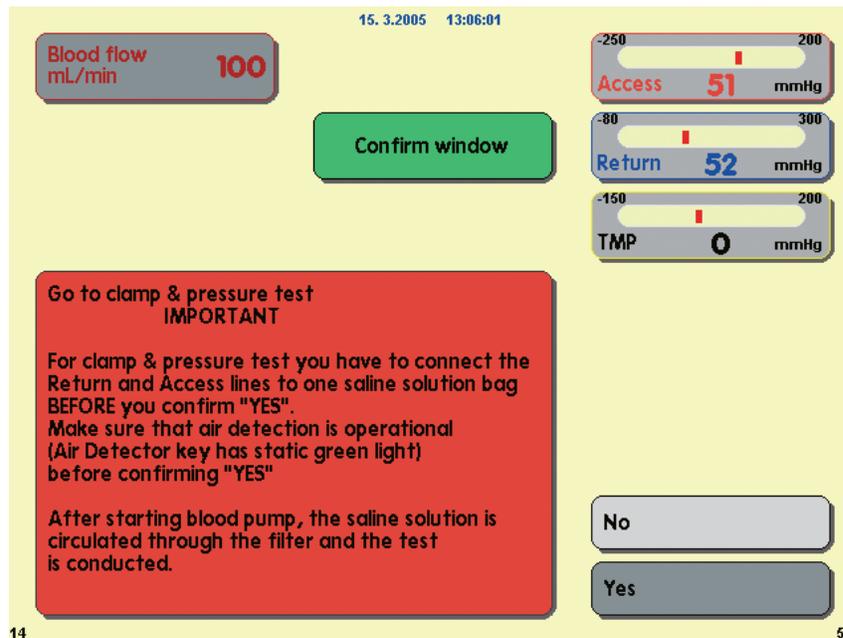
RECIRCULATION MODE
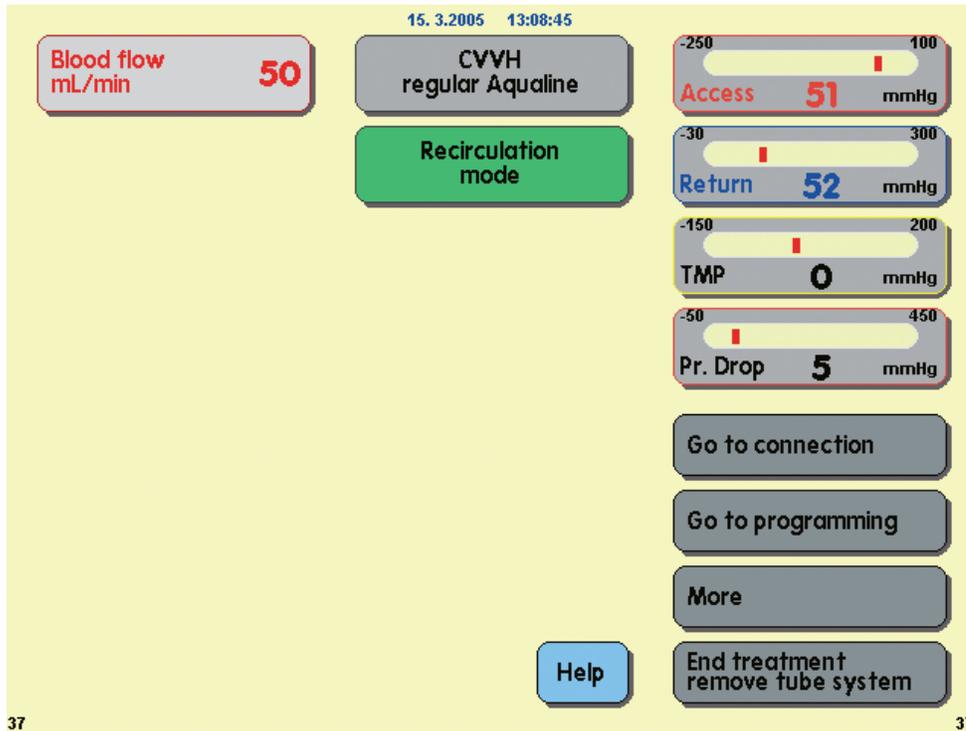
- Recirculation mode can be entered immediately after 'Clamp & pressure test' or during a treatment when there's the need to disconnect a patient temporarily. Temporary disconnection will be discussed in the Disconnection and End Treatment sections
- Recirculation of normal saline through the circuit prior to patient connection may facilitate the removal of air trapped in the circuit[1]
- Recirculation may be continued through the blood circuit until connection is needed
- Programming of prescribed parameters may be done during recirculation (recommended)
- Select 'Go to programming' at any time during recirculation to enter treatment parameters

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[1] Dr. Patrick Honore and Dr. Didier Journois

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PROGRAMMING AQUARIUS

- All parameters are programmed in this screen

- Each parameter shows a yellow screen that provides detailed information about <u>the selected parameter only</u>

- Programming can be done after priming, during recirculation, or immediately before connection to the patient. Parameters may also be adjusted at any time during treatment
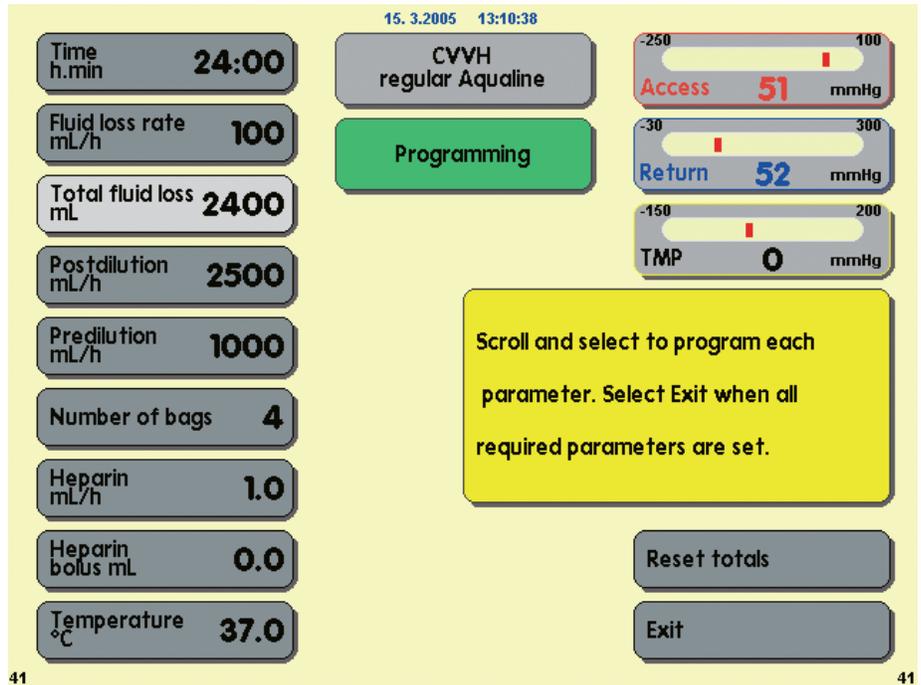
- Select 'Previous' to return to the main screen

- Select 'Go to connection' when ready to connect the patient

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Time h.min	24:00
Fluid loss rate mL/h	100
Total fluid loss mL	2400
Postdilution mL/h	2500
Predilution mL/h	1000
Number of bags	4
Heparin mL/h	1.0
Heparin bolus mL	0.0
Temperature °C	37.0

CVVH regular Aqualine

Programming

-250 ... 100
Access 51 mmHg

-30 ... 300
Return 52 mmHg

-150 ... 200
TMP 0 mmHg

Scroll and select to program each parameter. Select Exit when all required parameters are set.

Reset totals

Exit

41   41

USING THE SELECTOR BUTTON:

Turn: to highlight the parameter
Push once: to select the parameter
Turn right: to ⬆
Turn left: to ⬇
Push once: to confirm new values

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PROGRAMMING PARAMETERS

The parameters available include:

Parameter	Description
Time h.min 24:00	This parameter is optional and may be left at 0:00 h:min, unless the fluid removal rate is set to 0 mL/hour. When set, the Aquarius will run for the indicated length of time and then displays the message 'Therapy target achieved by time'. The operator may now program more time to continue the treatment or move to the disconnection phase
Fluid loss rate mL/h 100	Enter the amount of fluid that is prescribed for the patient to lose per hour
Total fluid loss mL 2400	Enter the amount of fluid to be removed. After this goal is achieved, the Aquarius will display the message 'Therapy target achieved by fluid loss'. If there is a fluid loss rate set, then this value must be programmed
Postdilution mL/h 2500	Available in CVVH and CVVHDF modes only, this is the amount of fluid that will be delivered post-filter
Dialysate mL 0	Available in CVVHD and CVVHDF modes only, this is the amount of fluid that will be delivered as dialysate
Predilution mL/h 1000	Available in CVVH mode only, this is the amount of fluid that will be delivered pre-filter
Number of bags 4	The number of bags hanging from the substitution/dialysate scale. An equal number of empty bags must also be hung from the filtrate scale
Heparin mL/h 1.0	This is the infusion rate from the integrated anticoagulation syringe pump in mL/hour
Heparin bolus mL 0.0	If a bolus of heparin is prescribed, enter it here for immediate administration when in treatment mode
Temperature °C 37.0	When set at 0, the fluid warmer will be off. It is adjustable from 35° to 39° C (95° to 102.2° F). The warmer heats both substitution and dialysate fluid
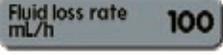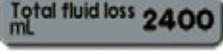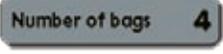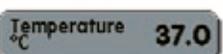
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CONNECTION MODE
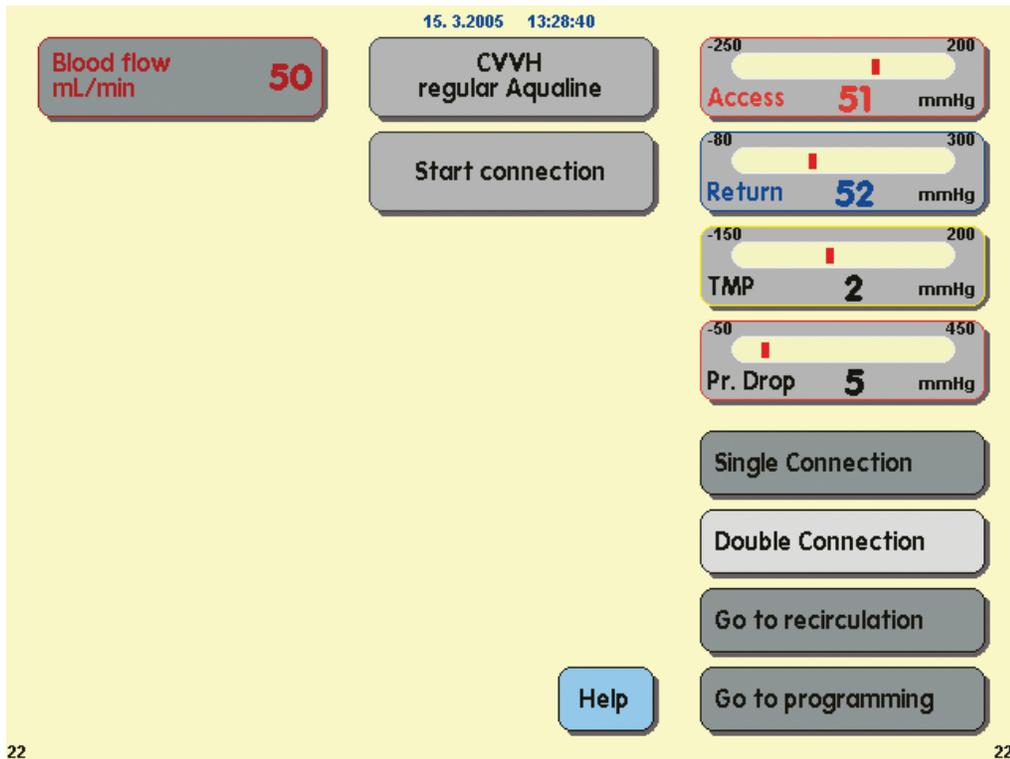
- Select Single Connection or Double Connection and follow the instructions on the screen

  Single Connection   Only the access line is attached to patient's access port, initially, and the blood pump is started to discard the saline from the circuit, up to the air detector. A blood sensor, located inside the air detector, will automatically stop the pump

  Double Connection   Both access and return lines are simultaneously attached to the patient's access and return ports

- Press Blood Pump key to start treatment

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Lesson 3: Treatment Mode

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TREATMENT MODE
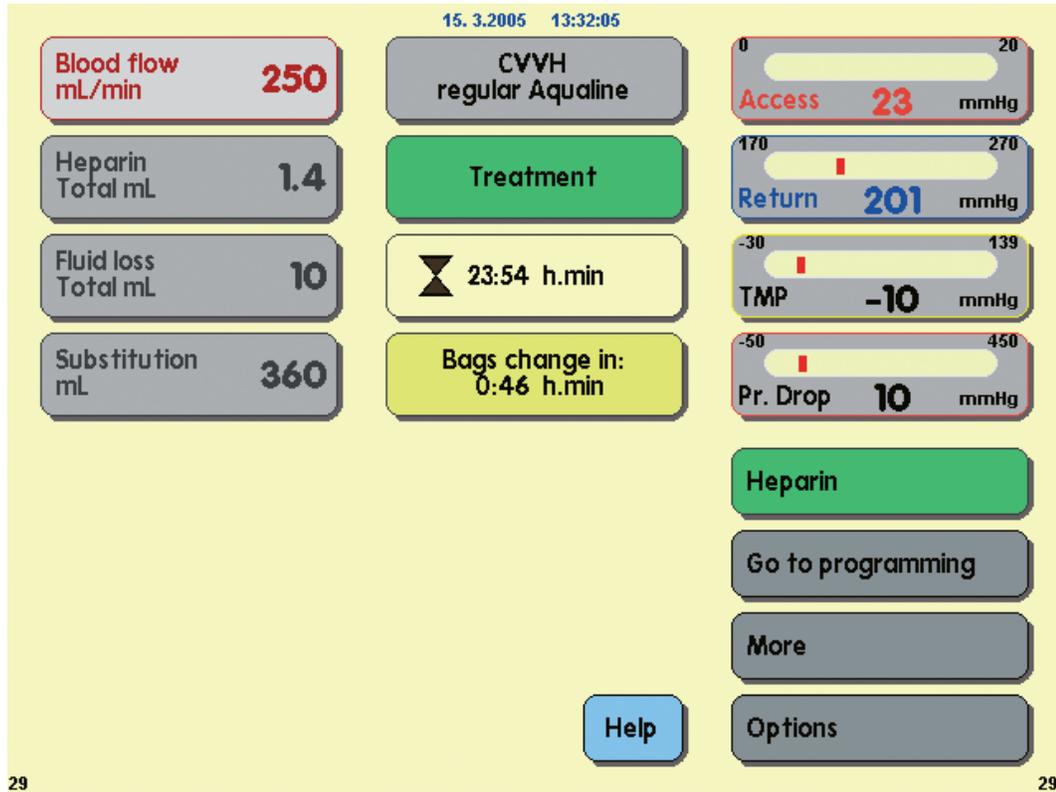
The 'Treatment' screen displays pertinent information and allows the operator to monitor several parameters throughout the therapy:

- Blood flow

- Cumulative totals of fluid loss and substitution/dialysate since last total reset (heparin is not reset) **Reset totals**

- Pressures (Access, Return, TMP and Pressure Drop)

    - See detailed information on Pressures in Module 2 Lesson 4

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- Screen selection choices:
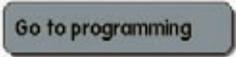
Go to programming

Allows the operator to return to the programming screen any time during treatment to change parameters

More

Allows the operator to view additional treatment information, with no ability to make changes

Options

Provides the following options:
- View history
- Go to recirculation
- End treatment
- Change syringe
- Change therapy

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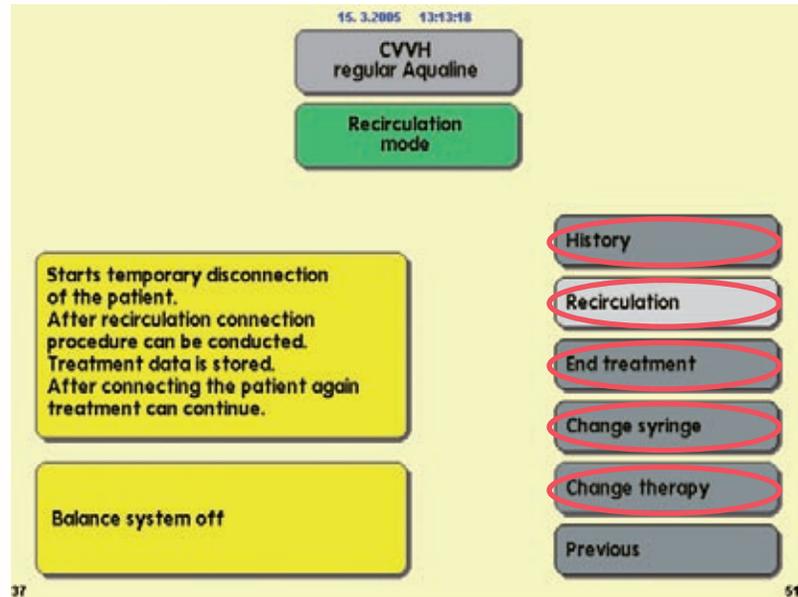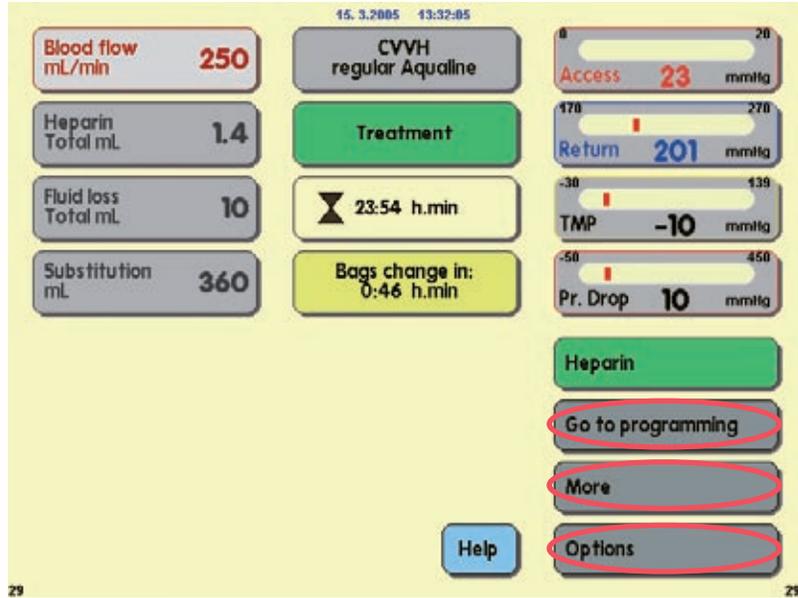
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The history of the last three treatments is available. Data is visible as a list or a graph. Pressures, programmed parameters, patient data and events are stored.
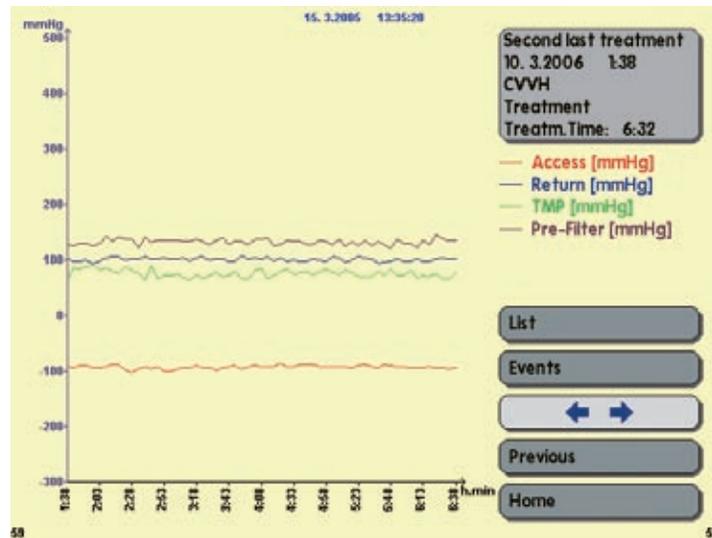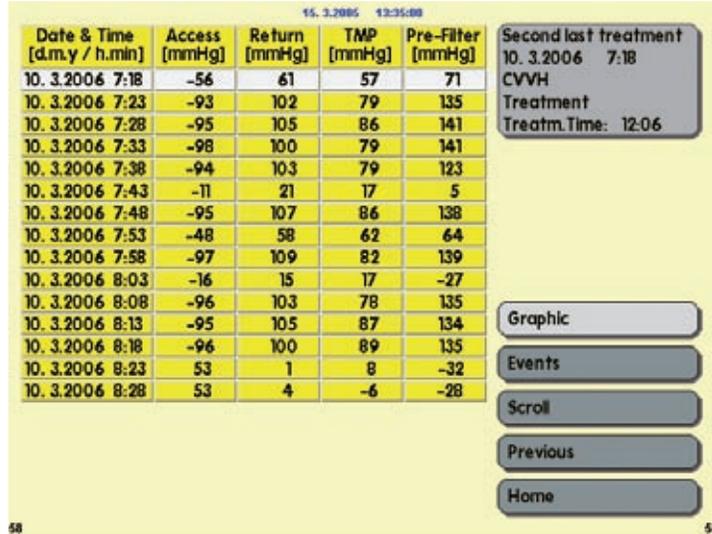
Notes:

DISCONNECTING PATIENT FROM AQUARIUS

The patient may be disconnected from the Aquarius by selecting and confirming 'Recirculation' or 'End treatment' from the 'Options' screen.

• Disconnecting the patient from the 'Recirculation' screen allows temporary disconnection for a limited period of time. The filter, lines, bags and solutions all remain on the machine and the blood pump runs in recirculation mode until the patient is ready to be reconnected to the same circuit

• Disconnecting the patient from the 'End treatment' screen will mean the patient treatment will end. The filter lines, bags and all solutions must be removed from the machine and Aquarius must be turned off. A new set up will be needed if the patient therapy is to be continued

➡ REMINDER: When disconnecting patients from Aquarius, there may be circumstances in which blood should NOT be returned to the patient. These circumstances may include, but are not limited to: cardiac arrest, fluid overload, major blood leak, a circuit that was primed with blood or albumin, hemolysis or a clotted circuit. Always check with the prescribing physician.[2]

ⓘ NOTE: The following supplies may be needed:

1. One bag of normal saline for rinsing blood back to patient

2. Two saline syringes and the prescribed anticoagulant to lock the vascular catheter

3. Caps for the vascular catheter

⚠ CAUTION: Always follow hospital policy for standard precautions. Gloves, mask and a face shield should be worn when connecting or disconnecting blood lines from patients and removing lines from Aquarius

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[2] Dr. Noel Gibney

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RECIRCULATION MODE FOR TEMPORARY DISCONNECTION
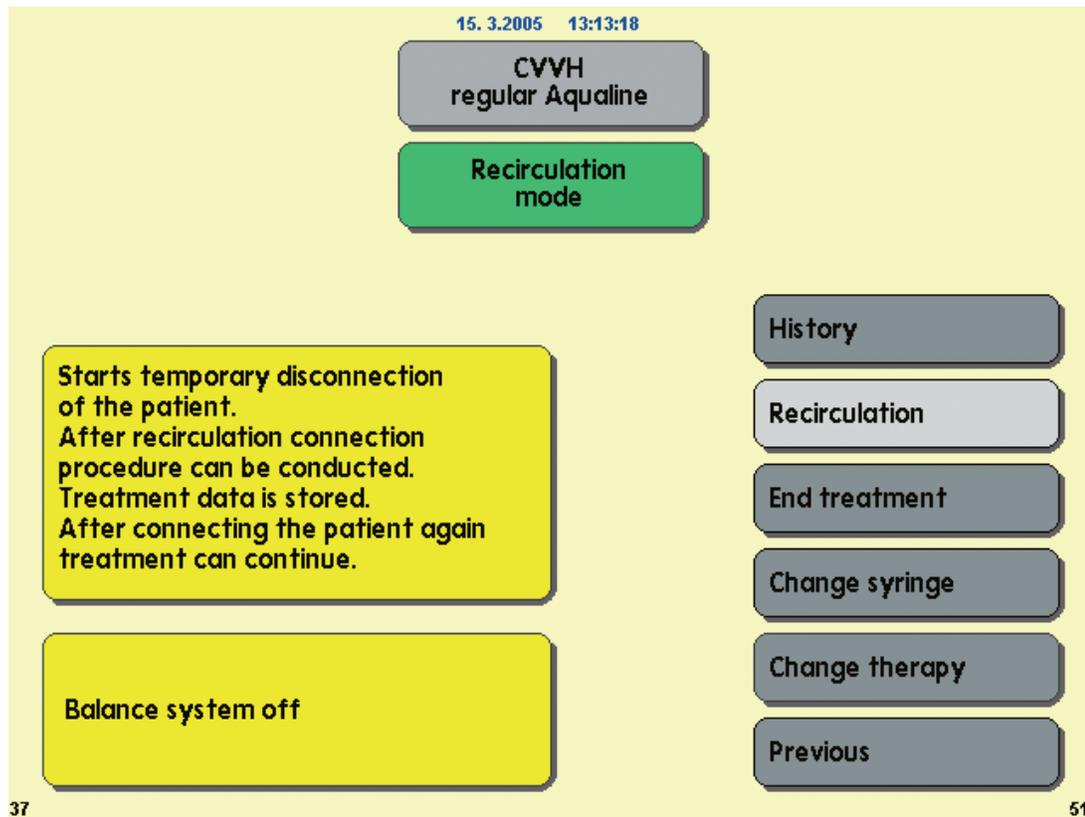
- Go to the 'Options' screen and select Recirculation
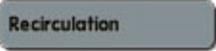
- This option starts the temporary disconnection of the patient. The screen menu guides the operator through the disconnection procedure
- On-screen directions guide the operator through the access and return disconnection process
- Volume of reinfusion fluid is displayed
- All treatment parameters are stored in 'History'

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END TREATMENT MODE

- Before ending treatment, please record all pertinent data from the 'Treatment' screen

- To end the treatment and disconnect the patient from the Aquarius, go to the 'Options' screen and select
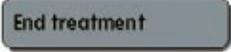
  End treatment

  ➤ REMINDER: Once you confirm the 'End treatment' selection, you will not be able to go back

- Follow instructions on the screens to disconnect the patient from the Aquarius

- The volume of fluid used to return blood to the patient will be recorded on the disconnection screens as the reinfusion volume in milliliters

  Reinfusion ml   21
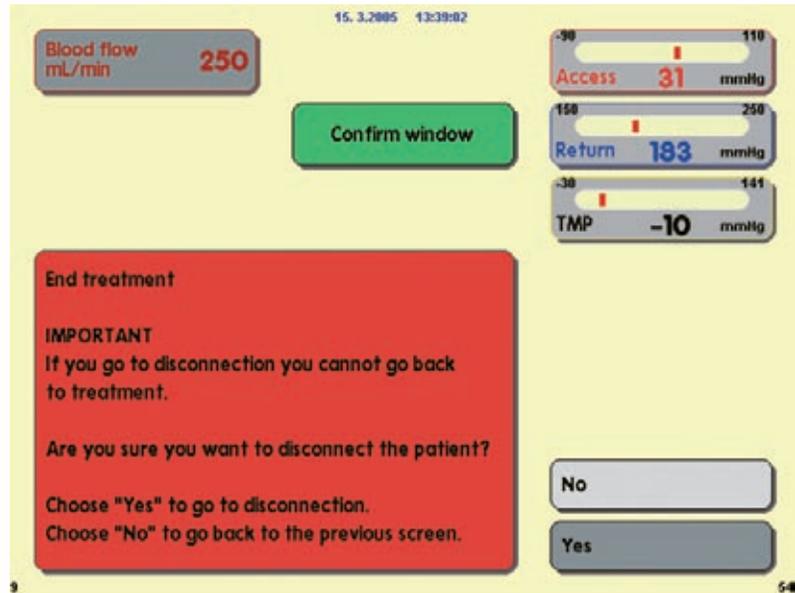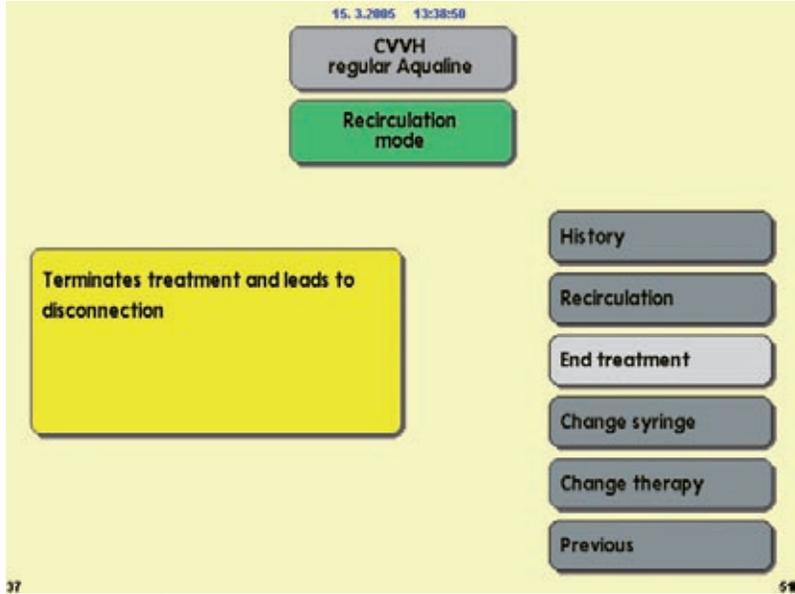
Notes:

- If system has clotted and any circuit pressure is greater than 400 mmHg, follow on-screen instructions for relieving pressure

  ⚠ WARNING: Removing Aqualine under high pressure conditions may lead to a blood leak or membrane rupture in pressure domes

- Remove Aqualine and bags from Aquarius

  ⚠ WARNING: Never switch off the Aquarius before the tubing set is completely removed

- Aquarius off is highlighted. Push the selector button to turn the Aquarius off
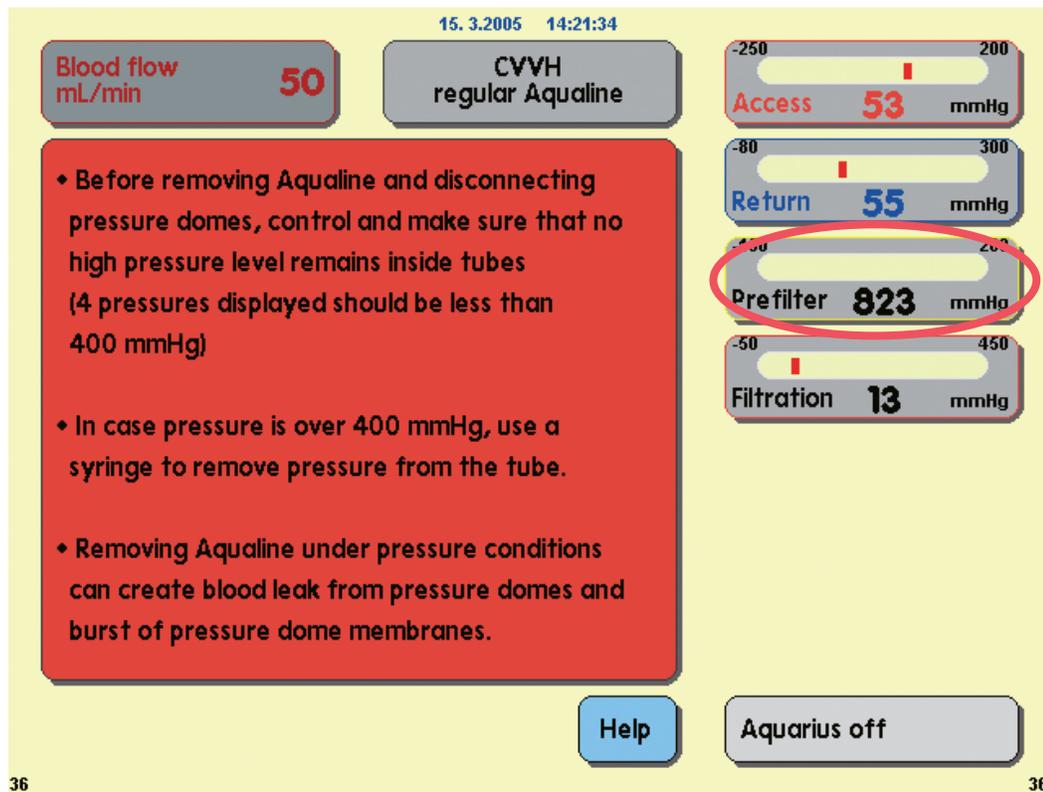
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Lesson 4: Pressures, Alarms and Fluid Balance

CRITICAL CARE
NEPHROLOGY | alliance

Edwards
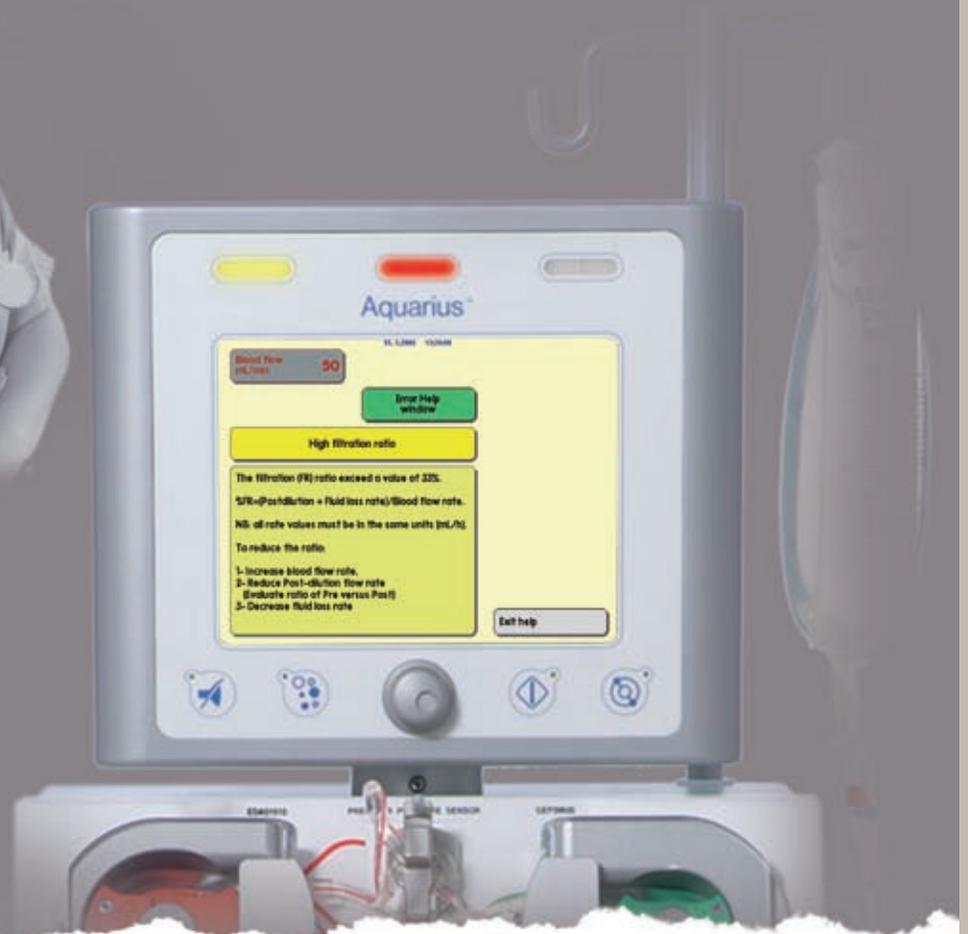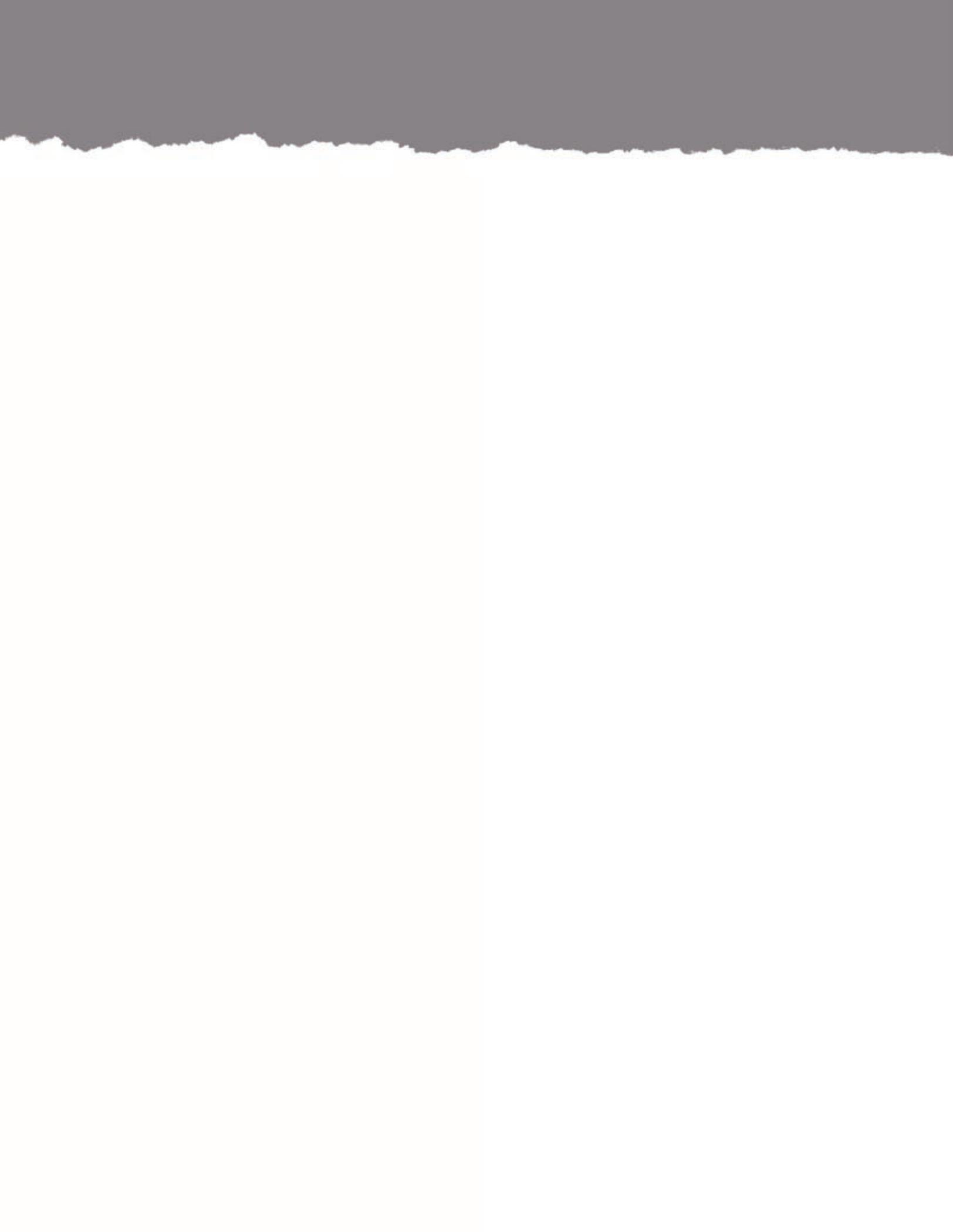
AQUARIUS PRESSURE MONITORING

All extracorporeal circuits are run by pressures. Aquarius uses four pressure readings to monitor and control the system. Three pressures (Access, Return and Pre-filter) monitor the blood side and one pressure (Filtrate) monitors the fluid side. All four pressures are used in combination to help you manage the treatment safely and effectively.

ACCESS PRESSURE

- Typically monitors the negative pressure generated to remove blood from the patient
- Access pressure may be positive under certain conditions (example: ECMO)
- The patient's catheter and Aquarius' blood flow rates affect this pressure
- Measuring range: -250 to +100 mmHg
- Upper alarm limit: automatic setting between -50 and +100 mmHg
- Lower alarm limit: automatic setting between -250 and -100 mmHg
- Alarm window size during treatment: +/-100 mmHg around the actual value
- Displayed on the 'Treatment' screen
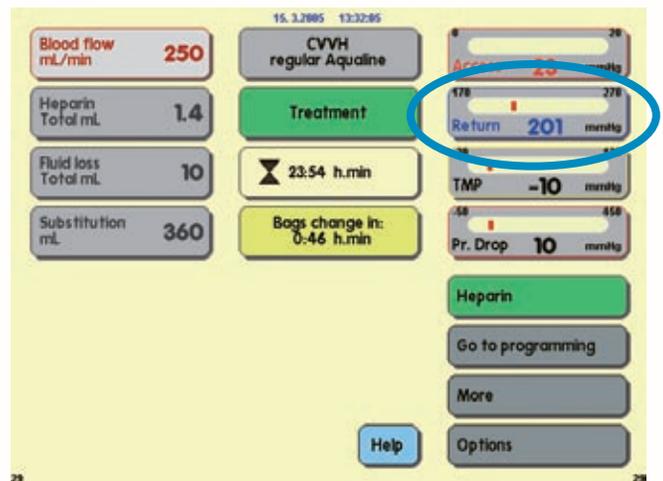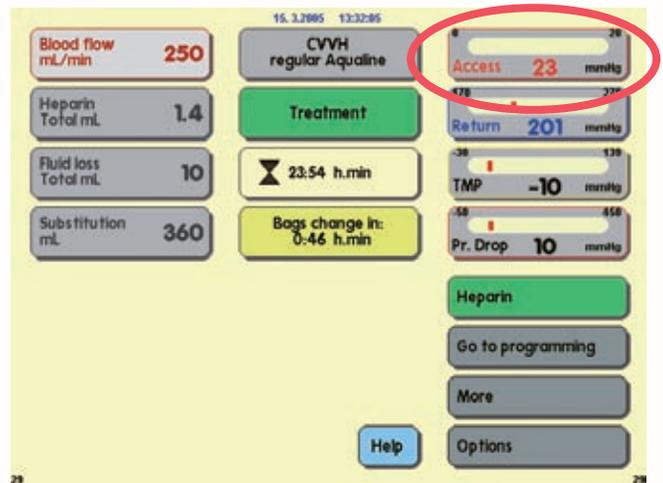
RETURN PRESSURE

- Monitors the positive pressure generated to return the blood to the patient
- The patient's catheter and Aquarius' blood flow rates affect this pressure
- Clotting in circuit affects this pressure
- Measuring range: 0 to +350 mmHg
- Upper alarm limit: automatic setting between 110 and 350 mmHg
- Lower alarm limit: automatic setting between 10 and 250 mmHg
- Alarm window size during treatment: +/-100 mmHg
- Displayed on the 'Treatment' screen

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PRE-FILTER PRESSURE

- Monitors the <u>positive pressure</u> generated in the circuit immediately before the blood enters the hemofilter
- Blood flow rate and return pressure affect this pressure
- Highest pressure point in the circuit
- A rising pre-filter pressure may be indicative of filter clotting
- Upper limit: +400 mmHg
- Lower limit: -100 mmHg
- Displayed on the More screen
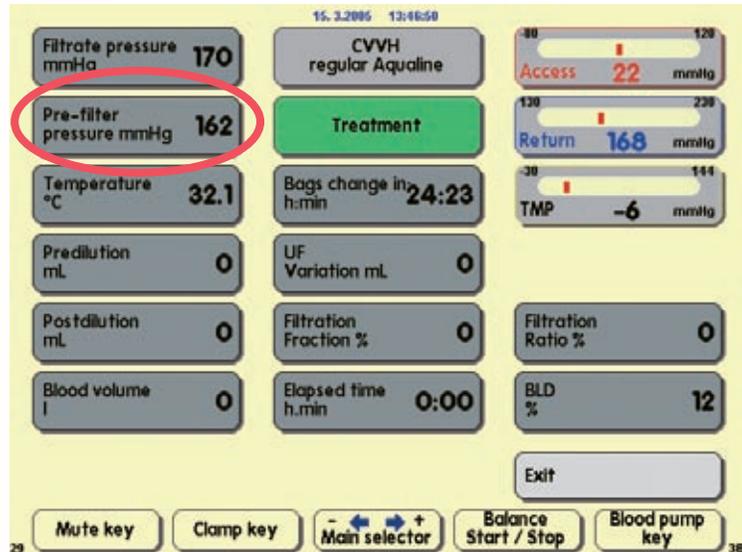
FILTRATE PRESSURE

- Monitors the negative and/or positive pressure generated in the filtrate compartment of the hemofilter. This affects the movement of fluid across the membrane
- A rising filtrate pressure may be indicative of filter clotting
- Blood flow rates and fluid flow rates affect this pressure
- Upper limit: +400 mmHg
- Lower limit: -400 mmHg
- Displayed on the 'More' screen

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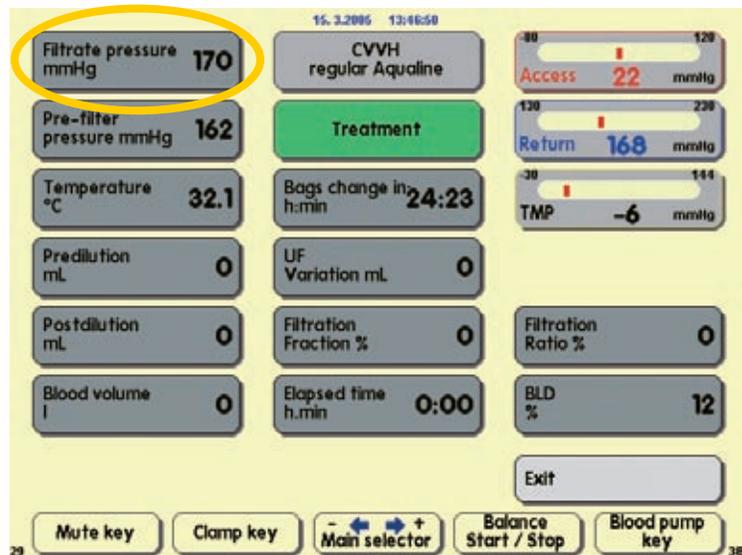
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TMP (TRANSMEMBRANE PRESSURE)

- Calculated using Return, Pre-filter and Filtrate pressures
- Calculated as: $\dfrac{\text{Return Pressure} + \text{Pre-filter Pressure}}{2} - \text{Filtrate Pressure}$

- TMP is a combination of the total pressure exerted on the membrane (positive pressure inside the fibers and negative pressure outside the filters)
- Upper limit: +400 mmHg (CRRT)
- Upper limit: +100 mmHg (TPE)
- Lower limit: -30 mmHg
- Displayed on the 'Treatment' screen
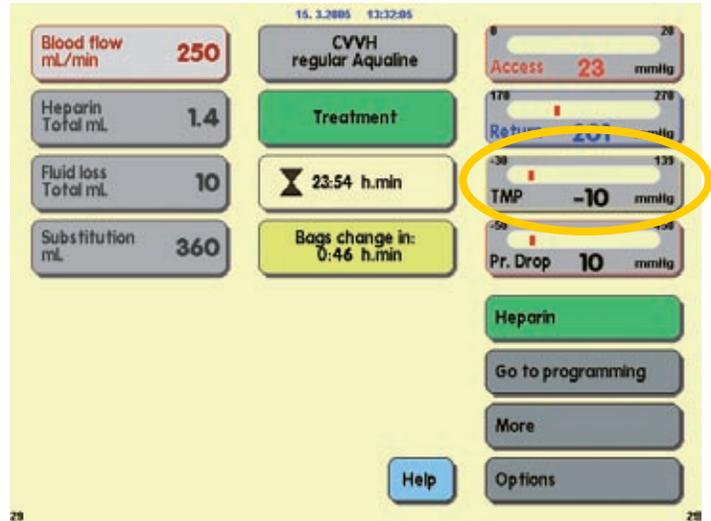
PD (PRESSURE DROP)

- Calculated using pressure loss from top to bottom of hemofilter
- Length of hemofilter affects pressure
- Calculated as:
  Pre-filter Pressure – Return Pressure
- Displayed on the 'Treatment' screen

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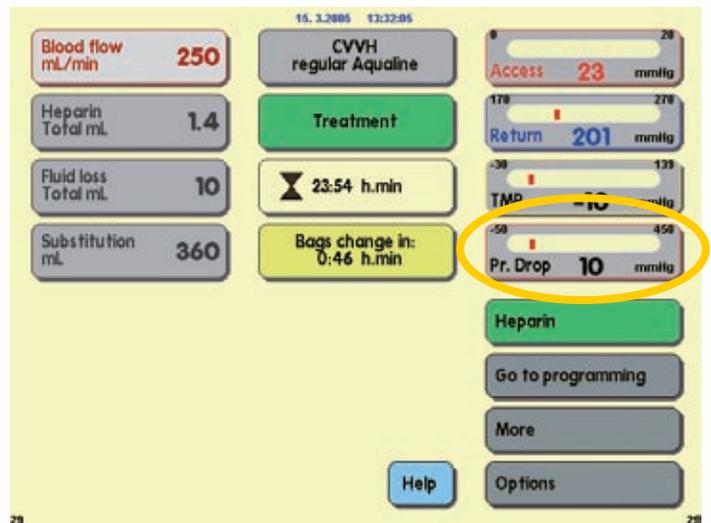
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AQUARIUS ALARMS

The Aquarius safety mode is determined by the nature of occurring alarms:

Alarm type	Aquarius safety mode
Alarms in blood circuit	• Stops all pumps • Closes return line clamp • Generates visual and audible alarms
Alarms in filtrate / dialysate circuit	• Stops filtrate pump • Stops pre-dilution pump and post-dilution pump • Generates visual and audible alarms
System error	• Stops all pumps • Closes return line clamp • Generates visual and audible alarms

- Alarm signals are <u>audible</u> and <u>visual</u>
- The status lights change from green to red, yellow, or a combination depending on the type of alarm
- Cause of the alarm is displayed in a message box in the lower left corner of the screen
- Alarms may be silenced for two minutes by pressing the Mute key
- Blood circuit alarms are cleared by pressing the Blood Pump key. Once the blood pump has been restarted, press the Balance Start/Stop key to restart the fluid pumps
- Fluid circuit alarms are cleared by pressing the Balance Start/Stop key

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BLOOD CIRCUIT ALARMS

- Generates audible and visual alarm
- Stops all pumps
- LED in Blood Pump and Balance Start/Stop key flashes
- Closes return line clamp (if air detected or return pressure drops below lower limit of +10 mmHg)

FLUID CIRCUIT ALARMS

- Generates audible and visual alarm
- Stops all fluid pumps
- LED in Balance Start/Stop key flashes
- Blood Pump continues to run

> **ℹ NOTE:** A Balance alarm occurs when a 50 mL (20 mL with use of Aqualine S) difference is detected between the fluid volume pumped and the scale measurement of the substitution or filtrate solutions. This volume may result in an additional 50 mL (20 mL) infusion to the patient or 50 mL (20 mL) of fluid removed from the patient if a tubing line is kinked or blocked. Correct the cause of the alarm and press the Balance Start/Stop key to resume treatment

> **⚠ WARNING:** If repeated balance alarms occur, stop treatment to protect the patient from excessive fluid removal or overload. Call technical support to resolve the problem. Do not use the machine until it has been repaired

SYSTEM ALARMS

- Generates audible and visual alarms
- Stops all pumps
- LED in Blood Pump and Balance Start/Stop key flashes
- Closes return line clamp (if air detected or return pressure drops below lower limit of +10 mmHg)

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TROUBLESHOOTING SYSTEM ERRORS, ALARMS AND MESSAGES

System Errors: Red indication

If the following system errors are not corrected after system test and if during treatment no correction is possible, please call technical service to repair the Aquarius.

During the system test (after switching the system on) and also during operation the Aquarus system automatically performs tests to check the safety-critical components. If errors occur during these tests, the system switches to the safety mode and generates a system error message. This error message appears with the abbreviation CPU1 (control processor unit1) or CPU2.

Display:	Cause:	Options for error removal:
Access sensor	• Access pressure values deviate from limits. • Control system and protective system values deviate from each other (outside of limits) • During clamp/pressure test no pressure increase is detected	√ Restart system (no tubing must be installed). If the error cannot be reset, put system out of operation and notify technical support. √ Access pressure dome may not be connected correctly (ensure by pressing the dome firmly towards the access transducer)
ADC/Voltage	• Voltage supply or AD-converter failure	√ Restart system (no tubing must be installed). If the error cannot be reset, put system out of operation and notify technical support.
Air detector	• Air detector test failed.	√ Press blood pump key. If error cannot be reset, put system out of operation and notify technical support.
Backup	• No dates at the backup	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
Balance filtration	• Check filtration scale • Values between protective and control system deviate from each other (outside of limits). • Actual values are outside of limits.	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
Balance substitution	• Check substitution scale • Values between protective and control system deviate from each other (outside of limits). • Actual values are outside of limits.	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
BLD (Blood leak detector)	• Blood leak detector does not work properly.	√ Press the Blood pump key. If the system error cannot be reset, put system out of operation and notify technical support.

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Display:	Cause:	Options for error removal:
Blood pump	• Flow rate test failed. • Blood pump drive defective. • Blood pump is not stopped. • Actual value of number of revolutions deviates from set value outside of limits.	√ Switch system off and on again after approx. 1 minute (no tubing must be installed). √ Press blood pump key. √ If the error cannot be removed, notify technical support.
Clamp doesn't close **Clamp doesn't open**	• Clamp test failed. • Clamp does not close. • Clamp does not open.	√ Correct tubing set position in clamp. √ Press blood pump key. If the error cannot be reset, put system out of operation and notify technical support.
CODE	• Controller CPU program code test failed • Master CPU program code test failed	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support
Commu front system	• Data transfer to display system defective.	√ Set up safety mode for the patient. √ Switch system off and on again after approx. 1 minute (no tubing must be installed). If the error cannot be reset, put system out of operation and notify technical support.
Commu protection system	• Error during data transfer. • Power supply for protective system is defective.	√ Press blood pump key or Balance Start/Stop key. √ Switch system off and on again after approx. 1 minute. If the error cannot be reset, put system out of operation and notify technical support.
EEPROM	• Master CPU calibration data test failed • Controller CPU calibration data test failed	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support
Error1 CPU	• Master CPU Register test failed • Controller CPU Register test failed	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support
Error2 CPU	• Master CPU RAM test failed • Controller CPU RAM test failed	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support
Error3 CPU	• Master CPU jump test failed • Controller CPU jump test failed	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support
Error blood detection	• Blood at optic sensor (airdetector)	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.

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Display:	Cause:	Options for error removal:
Filtration pump	• Flow rate test failed. • Filtrate pump drive defective. • Filtrate pump is not stopped. • Actual value of number of revolutions deviates from set value outside of limits.	√ Switch system off and on again after approx. 1 minute (no tubing must be installed). √ Press Balance Start/Stop key. √ If error cannot be reset, notify technical support.
Heparin pump	• Actual values of control and protective systems deviate from each other (outside of limits) • Actual values deviate from limits	√ After selftest: Restart system (no tubing must be installed). If the error cannot be reset, put system out of operation and notify technical support. √ During treatment: 1. Check the Heparin line is not clamped. 2. Go to "Options" and "Change Syringe", following the on-screen text. Please Note: You DO NOT have to remove the syringe during this process 3. If problem persists, program the pump to 0, clamp the line and remove the syringe. If problem persists, end treatment and call technical service.
Heater	• Master hasn't pass the system test	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
Operation mode	• The data transfer values regarding the operation mode deviate between master- and controller CPU.	√ Press blood pump key to start a new check. √ If the alarm appears again, call technical support.
Postdilution pump	• Flow rate test failed. • Postdilution pump drive defective. • Postdilution pump is not stopped. Actual value of number of revolutions deviates from set value outside of limits.	√ Switch system off and on again after approx. 1 minute (no tubing may be installed). √ Press Balance Start/Stop key. √ If the error cannot be reset, put system out of operation and notify technical support.
Program run	• Program failure Master CPU • Program failure Controller CPU	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.

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Display:	Cause:	Options for error removal:
Predilution pump	• Flow rate test failed. • Predilution pump drive defective. • Predilution pump is not stopped. • Actual value of number of revolutions deviates from set value outside limits.	√ Switch system off and on again after approx. 1 minute (no tubing must be installed). √ Press Balance Start/Stop key. √ If the error cannot be reset, put system out of operation and notify technical support.

Return sensor	• Return pressure values deviate from limits.
	• Values between protective system and control system deviate from each other (outside of limits).
	• During clamp/pressure test no pressure increase is detected
		√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
		√ Clamp pressure test:
		  o Press domes firmly towards the transducer. Return and pre filter domes must be connected correctly
		  o Insert tube into return line clamp
		  o Ensure that there is no leakage between blood pump and return line clamp

Sensor Voltage	• Voltage supply or AD-converter failure	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
Software version	• Different Software version detected at master and controller	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
Timer	• Timer difference between master and controller > 20%	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
TMP sensor	• Filtrate and/or prefilter pressure values deviate from limits. • Values between protective system and control system deviate from each other (outside of limits)	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.
Vcc Master/communication	• RAM, EPROM or EEPROM are defective.	√ Switch system off and on again after approx. 1 minute. If the system error cannot be reset, put system out of operation and notify technical support.
XRAM	• Master CPU extern RAM failed • Controller CPU external RAM test failed	√ Restart system (no tubing may be installed). If the error cannot be reset, put system out of operation and notify technical support.

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Alarms: Red Indication

If the Aquarius system detects an out-of-range condition during the system test or during operation or if parameters exceed or drop below the respective limits, an alarm message is generated and the Aquarius system switches to the safety mode.

Display:	Cause:	Options for error removal:
High access pressure **Low access pressure**	Access pressure has exceeded the upper alarm limit. Access pressure has dropped below the lower alarm limit.	√ Check access blood line, including access and pre-filter sensors, for kinks or occlusions. √ Check position of patient access. √ Check blood flow rate.
Air Detected	Return tubing line contains air or micro-foam.	√ Make sure that tubing line does not contain air. √ Check access and filter connections for sources of air leaks. √ When you clear the Air Detected alarm, make sure there is no air or foam trapped in the line between the return detector chamber and the patient end. √ To remove air from the tubing line: **Step1.** Open the *return* line clamp. **Step 2.** Remove all air from the tubing set. **Step 3.** Close the *return* line clamp. **Step 4.** Resume treatment by starting the blood pump. ⚠ **Warning! If the air detected alarm does not clear and air is visible in the venous de-aeration chamber, disconnect the patient from the instrument and recirculate per your center's procedure.** *Note:* You may see micro-bubbles smaller than the air detector sensitivity.
Balance system off	The balance system has been off for 5 minutes.	√ Switch on

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Display:	Cause:	Options for error removal:

Balance Alarm
Check substitution line
Or
Balance alarm
Check filtration line
	Balancing deviates from the set values entered by the operator.	√ Check flow rates of the pumps.
		√ Check fluid removal and turnover input parameters.
		    Note: Potentially pumps can't deliver program with
		    very high volume because of pressure peaks.
		√ Check bag hanging on scale.
		    (Filtration or substitution)
		√ Check tubing set for narrow sections.
		    (Filtration or substitution lines) .

Blood leak	Filtrate / plasma contains blood.	√ Check filter for blood leak and exchange filter if required. √ Check pressure conditions.
Blood flow failure	The number of revolutions of the pump exceeds or falls below the alarm limits by ± 5%.	√ Restart blood pump. √ If problem persist call technician
Blood pump off	The blood pump was manually switched off for 1 minute.	√ Press blood pump key to switch blood pump on again.
Check transducer connections	The pressure domes have not detected any pressure change for 15 seconds.	√ Ensure the domes are properly connected.
Clamp heparin line	The Heparin syringe has been removed	√ Clamp Heparin line
Degassing chamber missing	The substitution degassing chamber is not inserted or the sensors are defective.	√ Insert the substitution chamber properly. Ensure the chamber is in contact with the sensor of the holder. If this doesn't help switch off heater to end the treatment. Then call technical service.
High filtrate pressure **Low filtrate pressure**	Filtrate pressure exceeds or falls below the alarm limits.	√ Check pressure sensor. √ Check tubing set for narrow sections. √ Check filter and exchange if required. √ Check blood flow-to-fluid removal or blood flow-to turnover ratio.
Filtrate flow failure	The number of revolutions of the filtrate pump exceeded or fell below the alarm limits by ± 5%.	√ Restart treatment √ If problem persist call a repair technician
Heparin syringe missing	A Heparin rate has been programmed and no syringe has been inserted in the plunger. The Heparin syringe is not inserted properly	√ Insert Heparin syringe if Heparin is needed √ Set Heparin rate to zero (No Heparin required)

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Display:	Cause:	Options for error removal:
Indication battery high	At the power fail indication battery high voltage is detected	√ Change battery √ Control charging voltage √ Control AD-converter/CPU
Keyboard failure	A key press longer than 60 seconds. detected by master-cpu.	√ The keyboard needs repair
Line/substitution failure	A substitution deviation is detected that influences the patient balance	√ Check lines √ Check clamps √ Check bags √ Check for leakages
Master key transfer	A key press longer than 60 seconds. detected by master-cpu.	√ The keyboard needs repair √ The communication cable is defective
Main battery high	At the main battery high voltage is detected	√ Control charging voltage/unit √ Control/change battery √ Control AD-converter/CPU
Post-dilution failure	The number of revolutions of the Post-dilution pump exceeded or fell below alarm limits by ± 5%.	√ Restart treatment √ If problem persist call technician.
Pre-dilution failure	The number of revolutions of the Pre-dilution pump exceeded or fell below alarm limits by ± 5%.	√ Restart treatment √ If problem persist call technician.
Pump door	One of the pump doors open	√ Check if one of the pump doors is open √ Close the door
High pre-filter pressure **Low Pre-filter pressure**	The pre-filter pressure exceeds upper alarm limit.	√ Check pressure sensor. √ Check filter and exchange if required. √ Check blood flow. √ Check tubing set for narrow sections.
High return pressure **Low return pressure**	Return pressure exceeds or falls below the alarm limits.	√ Check return line for connection, kinks or occlusions. √ Check return pressure transducer. √ Check blood flow rate. √ Check position of patient access.
Syringe removed	The Heparin syringe has been removed	√ Check the heparin syringe

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Display:	Cause:	Options for error removal:
High Temperature Temperature controller high (Fluid pumps will not run)	A high temperature is detected in the substitution degassing chamber The substitution solution temperature is above 40 °C The plate temperature of the heater is above 57°C	√ Check the substitution line for kinks √ Open heater door to cool the heater down. √ If the alarm disappears the pump will start automatically
Low temperature	The substitution fluid temperature has been below 33°C for more than 10 minutes.	√ Check the heater bag √ Check substitution temperature
Temperature controller	High temperature of the heater at the controller	√ Open heater and cool down the plate temperature √ Restart treatment
Turn over failure	The substitution volume calculated by pump revolutions deviate more than 350g from the substitution volume measured on the scale	√ Check lines √ Check clamps √ Check bags √ Check for leakages
High TMP **Low TMP**	TMP exceeds or drops below respective alarm limits.	√ Check pressure sensor. √ Check tubing set for narrow line sections. √ Check blood flow-to-fluid removal or blood flow-to-turnover ratio.

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Messages: Yellow Indication

If the Aquarius detects out-of-range conditions or reminders that do not conform to the intended use of the system, the operator gets detailed information defined for the individual conditions and the system switches to the safety mode.

Display:	Cause:	Options for error removal:
Air detected, Clamp/Pressure test disabled	The air detector detected air in the *return* line.	√ Ensure the *return* tubing does not contain air. √ Ensure the *return* tubing is installed properly in the air detector sensor's clamping mechanism and is not scratched or damaged. √ After correcting the error, Select and confirm *Previous*, then perform the clamp/pressure test again to proceed. ⚠ **Warning!** **If the air detected alarm cannot be cleared, discontinue treatment and do not return the extracorporeal blood to the patient.**
Anticoagulant off	The Heparin rate is programmed to zero.	√ If Heparin is not required proceed to next screen. √ If Heparin is required, insert a syringe containing Heparin and program the desired Heparin rate.
Balance initializing…	Scales and fluid pumps initialize when the balance system is started.	√ This is just a reminder √ Occurs each time the balance system is turned ON
Balance system off	The balance system is off, all fluid pumps are stopped.	√ Correct the cause and switch the balance system on again.
Blood detected **(Blood pump stops)**	During the connection or recirculation phase blood is detected in the return line	√ The blood pump stops and starts now only for 5 seconds again. Switch to treatment mode
Blood pump off	The blood pump was manually switched off.	√ Press blood pump key to switch blood pump on again.
Change substitution bag **Change filtrate bag**	The filtrate bag has reached maximum permissible weight or the substitution solution bags do not contain solution.	√ Replace empty substitution solution bags with for new bags filled with solution √ Replace full filtrate bags with empty bags
Check access transducer	The access/ return dome is not properly connected.	√ During clamp and pressure test no pressure increase is found when the clamp is closed

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Edwards Lifesciences

Display:	Cause:	Options for error removal:
Check degassing chamber	The degassing unit system has detected a pressure issue.	√ - After Selftest: Degassing pressure sensor or degassing module defect. Don't use the Aquarius machine and call technician. √ - During use: Pressure sensor detects less than -300 mmHg. Degassing Filter is wet. Clamp the pressure line, disconnect filter from sensor and use a syringe to dry it. Reconnect the line and unclamp it.
Check lines	The postdilution pump has been stopped for longer than 3 min to regulate the fluid loss.	√ Check the substitution line and the filtration line if the bags are opened, all clamps are removed and the tubes and bag inputs are not kinked.
End of Treatment	End of Treatment	√ Disconnect patient or reprogram patient parameter
Exchange filter and set	The assumed filter life time of 72 hours has been exceeded or the total using time for the actual tubing set is more than 80 hours. (Including priming, connection, recirculation and treatment time)	√ Exchange filter and tubing set √ Disconnect and start a new treatment with new filter and a new tube system
Function not available	During treatment the 'Off' key is used	√ To switch off the machine, select 'End treatment', perform the disconnection program until the 'Aquarius off' mode
Filt./effluent bag change soon	Filtrate/effluent bag change in less than 10 minutes	√ Prepare the Filtrate/effluent bag change
Heater cools down	If balance system has stopped for a prolonged period, the heater plate temperature is above 43°C.	√ The pumps stop until the temperature is in a safe condition (below 42° C). This may take up to 10 min. The pumps will start automatically.
Heater self test running. **! Wait**	Heater Selftest is in progress when the start-priming screen is reach.	√ Wait until heater Selftest is completed. √ When heater Selftest is finished, the yellow light upper the screen become fixed (green diode still fixed during and after heater Selftest)
Heparin syringe missing	The Heparin syringe is not in the Heparin pump.	√ nsert a Heparin syringe in Heparin pump or program the Heparin rate to zero.

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Display:	Cause:	Options for error removal:
High filtration ratio	1. Fluid removal rate exceeds 33% of the blood flow rate. 2. Exchange of fluid or plasma across the membrane is too high in comparison to the blood flow rate. 3. The post dilution substitution rate is higher than what is acceptable for the current blood flow rate.	√ Decrease fluid removal or plasma exchange rate √ Increase blood flow rate √ Evaluate ratio of pre vs. post dilution substitution solutions.
Indication battery low	Power failure indication (beep) battery is low	√ The battery is automatically charged if you go on with this treatment. √ This message indicates that in the event of a power failure the Aquarius will beep less than 2 min
Insert BLD chamber	The blood leak detector has not been inserted into the blood leak chamber.	√ Insert the chamber √ Reprime to correctly fill up the chamber. √ Ensure no scratches or marks are present on the Aqualine chamber
Insert tube **Insert tube to air detector**	The air detection system is not operational after priming	√ Insert correctly return line into the air detection system. √ Make sure that the air detection system is well inserted, if not push it back firmly. √ Ensure the green light of the clamp key is lighting.
Main battery low	After a power failure, the main power supply battery must be charged.	√ The battery is automatically charged if you go on with this treatment. √ This message indicates that in the event of a power failure the Aquarius will run less than 2 min
Negative UF	A negative UF is programmed	√ This is just a reminder
No bag	No bag was hung on the scale	√ Hang empty collection bag and/or substitution solution bag on the scale
No fluid chamber detected	The substitution degassing chamber is not inserted.	√ Insert the chamber correctly
Power failure	The Aquarius machine has detected a power failure	√ Reconnect the Aquarius to main power supply √ Return the blood to the patient and start a new treatment if power from main power supply is available
Please program	Hourly fluid loss or fluid loss total is not programmed	√ Select programming mode and program both hourly fluid loss and fluid loss total.

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Display:	Cause:	Options for error removal:
Please wait	The balance system is stopped	√ This is an indication that the system will start automatically after some minutes.
Program dialysate	In CVVHD dialysate rate is not programmed.	√ Select programming and program a dialysate rate.
Program goal	Treatment goal is not programmed.	√ Select programming and program either time, fluid loss and fluid loss total, or both.
Program treatment pumps	In CVVH/CVVHDF pre- and post-dilution/post-dilution and dialysate are not programmed.	√ Select programming and program pre- and post-dilution or post-dilution and dialysate rate.
Pump door open	One of the pump doors is open.	√ Close pump door(s).
Read error help instructions	To solve the alarm further information is needed	√ Further information is available from the help screens.
Return pressure low	The return pressure is below 10 mmHg	√ During the first minute of treatment this is a reminder.
Syringe empty. Go to OPTION to change	The syringe located in the Heparin pump is empty.	√ Clamp Heparin line. √ Take syringe out of pump and disconnect from line. √ Fill new syringe with Heparin. √ Enter syringe volume and confirm. √ Place syringe in pump and connect line. √ Confirm
Subst./dialysate bag change soon	Substitution/dialysate bag change in less than 10 minutes	√ Prepare Subst./dialysate bag change
Too much weight	Too many bags are on the scale.	√ Ensure that the same number of substitution solution and filtrate bags hang on the scale hooks. √ Note: The maximum number of bags on the scale is 4 substitution solution and 4 filtrate bags.

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AQUARIUS FLUID BALANCE

ⓘ NOTE: Aquarius records all fluids as a <u>cumulative</u> number from the start of treatment

* Values are programmed in the 'Programming' screen

* Dialysate and/or substitution fluid are automatically removed by the Aquarius

* When programming 'Hourly patient fluid loss', a 'Total fluid loss' MUST also be programmed. Programming the time is optional

* Treatment proceeds until a programmed target is achieved

* When 'Patient fluid loss' is set at zero, time must be programmed

   ⓘ NOTE: When the target is reached, the message 'Therapy target achieved by fluid loss' (or time) is displayed. The target can be reprogrammed and the treatment continued

* Programmed patient fluid removal will be recorded hourly on the 'Treatment' screen as a cumulative value

* Non-Aquarius ins and outs for the patient must be calculated and controlled by the user

* UF variation is monitored and displayed in the 'More' screen. The accuracy is 50 mL for regular circuits, 20 mL for low volume circuits

* 'Reset totals' in the 'Programming' screen resets all cumulative totals for fluid loss, and dialysate and substitution fluid. Treatment clocks are also reset. These values are located on the 'Treatment' screen.

   ⓘ NOTE: Anticoagulant volumes are NOT reset

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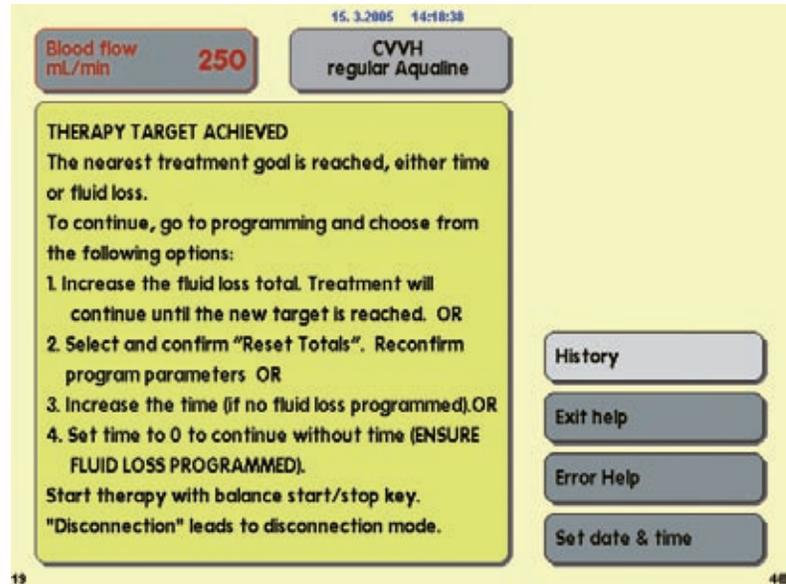
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Caution: Federal (U.S.) law restricts this device to sale by or on the order of a physician or other licensed practitioner. For safe and proper use of this device refer to the Operator's Manual.

Aquarius is distributed in the U.S. by:
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