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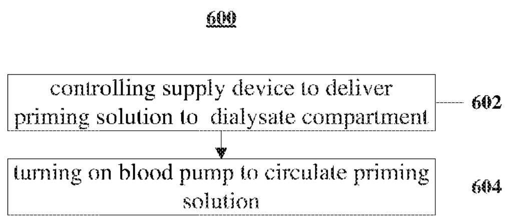

Figure 6

(57) Abstract: A priming method(300, 500, 600) and a priming apparatus(700), the priming method(300, 500, 600) comprising: controlling, on the condition that an arterial line(230) is blocked and a venous line(240) is opened, a supply device to deliver a priming solution to a dialysate compartment(222) of a dialyzer(220), wherein one end of the arterial line(230) with a blood pump(235) and one end of the venous line(240) with a venous chamber(244) are connected to a blood compartment(224) of the dialyzer(220) and the other end of the arterial line(230) and the other end of the venous line(240) are connected to a container(270, 275) via a connector(280, 285), and the priming solution in the dialysate compartment(222) crosses a membrane of the dialyzer(220) and enters into the venous line(240); turning on, after a predefined amount of priming solution is delivered into the dialysate compartment(222) by the supply device, the blood pump(235) to circulate the priming solution in an extracorporeal circuit composed of the arterial line(230), the blood compartment(224) and the venous line(240). The priming method(300, 500, 600) and the priming apparatus(700) can be applicable in the basic and advanced dialysis machines.

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PRIMING METHOD AND PRIMING APPARATUS

TECHNICAL FIELD

The present invention relates to a priming method and a priming apparatus.

BACKGROUND

A priming method to flush and clean of both blood tubing set and of a dialyzer is required for dialysis treatment preparation, wherein a physiological saline solution is commonly used as a priming solution which is also referred to a dialysate fluid.

For labor and cost saving, an online priming method with a dialysate fluid is advocated but it is mostly available from high-end machines with an online HDF function.

There is a prior art JP2011182992A2 which applies a back filtration method on a dialyzer to direct a dialysate fluid across a membrane of the dialyzer to an extracorporeal circuit of the dialyzer for priming. As shown in Figure 1A, an arterial line 30 was first primed with an arterial clamp 90 opened and a blood pump 50 run in a revered rotation while the dialysate fluid was delivered via the membrane with the back filtration method. In the second step, the arterial clamp 90 is closed and an electric clamp 94 is opened to store the dialysate fluid in a container 70 for reinfusion at the end of treatment. In the third step, the blood pump 50, the arterial clamp 90 and the electric clamp 94 are deactivated, and a venous clamp 92 is then opened to allow the dialysate fluid from back filtration to prime a venous line 40. Throughout the priming process, the arterial line 30 and the venous line 40 are connected to a waste bag to dispose the dialysate fluid.

However, the arterial clamp 90 and the electric clamp 94 are normally not available on basic dialysis machines. In addition, the blood pump 50 must run backwards (changes in electronics and mechanics). A rotor of the blood pump 50 causes higher occlusion pressures due to the backward rotation of the blood pump 50. These pressures must be monitored via the process control. Hardware modifications and cost are barriers to realize the priming method. Size of the waste bag can become relatively large (for example, about 2 liters to ensure effective priming) to hang on an IV pole. Storing the dialysate fluid in the container 70 for extended period of time, 4 hours for typical treatment, is questionable in terms of hygiene control.

CN101594894A is another prior art on the priming method. As shown in Figure 1B, the connections of a venous line 4 and an arterial line 5 at a patient side are in communication with two separate inlets 2, 3 of chamber of in particular a bag 1, and the connections of the venous line 4 and the arterial line 5 at a machine side are in communication with a dialyzer 6. A priming fluid is introduced before a blood pump 7. It has the advantage that where necessary a substantially larger volume of priming liquid can be circulated and therefore priming fluid consumption volume can be reduced. After circulation, the consumed priming liquid in the blood tubing set is advantageously replaced by refilling fresh priming liquid from a feed line 9 into the venous line 4 and into the arterial line 5, with the consumed priming liquid flowing out through the inlets 2, 3 into the bag 1. A substantially better flushing and cleaning of both the blood tubing set and of the dialyzer as well as an improved flushing out of any contaminants thereby results.

In the second prior art, the source of the priming liquid may either be the physiological saline fluid bag or the online priming fluid from an online HDF hydraulic. However, the online HDF hydraulic is only available in advanced dialysis machines.

SUMMARY

In consideration of the above deficiencies in the prior art, embodiments of the present disclosure provide a priming method and a priming apparatus, which are applicable in the basic and advanced dialysis machines.

A priming method according to an embodiment of the present disclosure includes: controlling, on the condition that an arterial line is blocked and a venous line is opened, a supply device to deliver a priming solution to a dialysate compartment of a dialyzer, wherein one end of the arterial line with a blood pump and one end of the venous line with a venous chamber are connected to a blood compartment of the dialyzer and the other end of the arterial line and the other end of the venous line are connected to a container via a connector, and the priming solution in the dialysate compartment crosses a membrane of the dialyzer and enters into the venous line; and turning on, after a predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the blood pump to circulate the priming solution in an extracorporeal circuit composed of the arterial line, the blood compartment and the venous line.

A priming apparatus according to an embodiment of the present disclosure includes: a controlling module for controlling, on the condition that an arterial line is blocked and a venous line is opened, a supply device to deliver priming solution to a dialysate compartment of a dialyzer, wherein one end of the arterial line with a blood pump and one end of the venous line with a venous chamber are connected to a blood compartment of the dialyzer and the other end of the arterial line and the other end of the venous line are connected to a container via a connector, and the priming solution in the dialysate compartment crosses a membrane of the dialyzer and enters into the venous line; and a turning-on module for turning on, after a predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the blood pump to circulate the priming solution in an extracorporeal circuit composed of the arterial line, the blood compartment and the venous line.

A control device according to an embodiment of the present disclosure includes: a processor; and a memory storing thereon executable instructions that, when executed, cause the processor to implement the above priming method.

A machine-readable storage medium according to an embodiment of the present disclosure stores thereon executable instructions that, when executed, cause a processor to implement the above priming method.

A dialysis system according to an embodiment of the present disclosure includes: a dialyzer; an arterial line with a blood pump, wherein one end of the arterial line is connected to a blood compartment of the dialyzer and the other end of the arterial line is connectable to a patient; a venous line with a venous chamber, wherein one end of the venous line is connected to the blood compartment and the other end of the venous line is connectable to the patient; a supply device for delivering priming solution to a dialysate compartment of the dialyzer when priming the dialysis system; and the control device.

In the embodiments of the present disclosure, only the blood pump, the air vent, the venous chamber, the venous clamp, the supply device, the connector and the container are necessary to realize priming of the dialysis system, and priming of the dialysis system according to the embodiments of the present disclosure is thus applicable in both the basic dialysis machines and the advanced dialysis machines because there are always the blood pump, the venous chamber, the venous clamp, and the supply device in the basic and advanced dialysis machines and the connector and the container are common and cheap.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, nature and advantages of the present disclosure will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout.

Figure 1A is a diagram schematic of a dialysis system according to a first prior art.

Figure 1B is a diagram schematic of a dialysis system according to a second prior art.

Figures 2A -2C are diagram schematics of a dialysis system according to a first embodiment of the present disclosure.

Figure 3 is a flowchart of a priming method according to a first embodiment of the present disclosure.

Figure 4A is a diagram schematic of a dialysis system according to a second embodiment of the present disclosure.

Figure 4B is a diagram schematic of a Y-connector according to an embodiment of the present disclosure.

Figure 5 is a flowchart of a priming method according to a second embodiment of the present disclosure.

Figure 6 is a flowchart of a priming method according to an embodiment of the present disclosure.

Figure 7 is a diagram schematic of a priming apparatus according to an embodiment of the present disclosure.

Figure 8 is a diagram schematic of a control device according to an embodiment of the present disclosure.

Figure 9 is a schematic diagram of a dialysis system according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

The detailed description set forth below, in conjunction with the appended drawings, is intended as a description of various configurations and is not intended to represent the only configuration in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of the various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well-known structures and components are shown in block diagram form in order to avoid obscuring such concepts.

Figures 2A -2C are diagram schematics of a dialysis system according to a first embodiment of the present disclosure.

As shown in Figure 2A, the dialysis system 200 may include a dialyzer 220, an arterial line 230 with a blood pump 235, a venous line 240 with a venous chamber 244, a venous clamp 246, an air vent 247 in communication with the venous chamber 244 and a level detector 248, a balancing system 250 and a control device 260.

The dialyzer 220 may include a dialysate compartment 222, a blood compartment 224 and a membrane between the dialysate compartment 222 and the blood compartment 224.

One end of the arterial line 230 is connected to the blood compartment of the dialyzer 220 and the other end of the arterial line 230 that is connectable to a patient is connected to a sterilized plastic bag 270 as a container via a Y-connector 280 hung on an IV pole 290. The arterial line 230 is opened to allow fluid flow when the blood pump 235 is turned on, and the arterial line 230 is blocked when the blood pump 235 is turned off. In this embodiment, the blood pump 235 will only run in a forward rotation when the blood pump 235 is turned on. Accordingly, an additional process control for monitoring the higher occlusion pressures is not necessary as in the case of the first prior art mentioned before, which does not result in hardware modifications and can save cost of priming of the dialysis system.

One end of the venous line 240 is connected to the blood compartment 224 of the dialyzer 220 and the other end of the venous line 240 that is connectable to the patient is connected to the plastic bag 270 via the Y-connector 280. The venous line 240 is opened when the venous clamp 246 is opened and the venous line 240 is blocked when the venous clamp 246 is closed. The venous chamber 244 is configured for separating air from fluid flowing through the venous chamber 244. The level detector 248 is installed on the venous chamber 244 and configured for detecting a liquid level of the liquid in the venous chamber 244 and outputting a signal indicating the detected liquid level. When the liquid level indicated by the signal outputted by the level detector 248 is less than a predefined liquid level, it means that there is an excessive air in the venous chamber 244. The excessive air in the venous chamber 244 may be removed by opening the air vent 247 and closing the venous clamp 246while there is fluid flow into the venous chamber. There is an extracorporeal circuit composed of the arterial line 230, the blood compartment 224 of the dialyzer 220 and the venous line 240 in the dialysis system 200.

The balancing system 250 serves as a supply device. The balancing system 250 is connected to the dialysate compartment 222 of the dialyzer 220 and is configured for delivering a priming solution to the dialysate compartment 222 of the dialyzer 220 when priming the dialysis system 200.

The control device 260 is connected to the blood pump 235, the venous clamp 246, the air vent 247, the level detector 248 and the balancing system 250 and is configured for controlling the blood pump 235, the venous clamp 246, the air vent 247 and the balancing system 250 to realize priming of the dialysis system 200, which will be described in details below. The control device 260 may be any device having computing capability, such as but not limited to a microcontroller or an industrial personal computer.

Figure 3 is a flowchart of a priming method according to a first embodiment of the present disclosure. The priming method 300 shown in Figure 3 will be explained in details below in conjunction with the dialysis system 200 shown in Figures 2A -2E.

As shown in Figure 3, at block 302, when it is necessary to prime the dialysis system 200, the control device 260 may turn off the blood pump 235 to block the arterial line 230 and close the venous clamp 246 to block the venous line 240.

At block 306, on the condition that the arterial line 230 is blocked and the venous line 240 is also blocked by closing the venous clamp 246, the control device 260 may control the balancing system 250 to deliver a first preset amount of priming solution into the dialysate compartment 222 of the dialyzer 220 so that the dialysate compartment 222 of the dialyzer 220 is primed with the priming solution, as shown by a line A with an arrow in Figure 2B.

At block 310, after the dialysate compartment 222 of the dialyzer 220 is primed with the priming solution, the control device 260 may open the venous clamp 246 to open the venous line 240, and turn off a valve in a return path of the balancing system 250 to block the return path of the balancing system 250 while the balancing system 250 continues to deliver the priming solution to the dialysate compartment 222 of the dialyzer 220. Blocking of the return path of the balancing system 250 will disable balancing function of the balancing system 250 and create a negative transmembrane pressure (TMP) between two sides of the membrane of the dialyzer 220, which causes the priming solution in the dialysate compartment 222 of the dialyzer 220 to cross the membrane of the dialyzer 220 and enter into the venous line 240 via the blood compartment 224 of the dialyzer 220, as shown by a line B and an line C in Figure 2B.

At block 312, after the valve in the return path of the balancing system 250 is turned off, the control device 260 may control the balancing system 250 to continue delivering the priming solution into the dialysate compartment 222 of the dialyzer 220, until an additional second preset amount of priming solution is delivered into the dialysate compartment 222 by the balancing system 250. The second preset amount of priming solution will cause the venous line 240 and the storage bag to be filled with the priming solution and a programmed amount of priming solution to be delivered through the venous line 240 into the plastic bag 270.

At block 314, after the second preset amount of priming solution is delivered into the dialysate compartment 222 by the balancing system 250, the control device 260 may control the balancing system 250 to stop delivering the priming solution to the dialysate compartment 222 of the dialyzer 220.

At block 318, after the balancing system 250 is stopped, the control device 260 may turn on the blood pump 235 to draw the priming solution in the plastic bag 270 to fill the arterial line 230 and then circulate the priming solution in the extracorporeal circuit as shown by a line E in Figure 2C. Herein, the plastic bag 270 is sterilized and thus the priming solution in the plastic bag 270 is also sterilized. In this case, the priming solution in the extracorporeal circuit is not contaminated when the arterial line 230 is filled with the priming solution in the plastic bag 270. During circulating of the priming solution in the extracorporeal circuit, the level detector 248 monitors a liquid level of the priming solution in the venous chamber 244 and outputs a signal indicating the liquid level of the priming solution in the venous chamber 244. Herein, if the liquid level indicated by the signal outputted by the level detector 248 is less than a predefined liquid level, it means that there is an excessive air in the venous chamber 244.

At block 322, the control device 260 may detect whether there is an excessive air in the venous chamber 244 based on the signal outputted by the level detector 248.

At block 324, if it is detected that there is an excessive air in the venous chamber 244, the control device 260 may open the air vent 247 and turn off the venous clamp 246 to remove the excessive air in the venous chamber 244, as shown by a line D in Figure 2C. Herein, after the excessive air in the venous chamber 244 is removed, the control device 260 will close the air vent 247, and open venous clamp 246 to restore opening of the venous line 240.

At block 326, if the control device 260 determines that there is no excessive air in the venous chamber 244 or the excessive air in the venous chamber 244 has been removed, the control device 260 may enable the blood pump 235 to run at a programmed blood pump speed for a period of time, which will circulate the priming solution in the extracorporeal circuit at the programmed blood pump speed for the period of time.

At block 330, after the period of time lapses, the control device 260 may turn off the blood pump 235 and control the balancing system 250 to deliver the first preset amount of fresh priming solution into the dialysate compartment 222 of the dialyzer 220 when the return path of the balancing system 250 is not blocked, which causes the dialysate compartment 222 of the dialyzer 220 to be primed with the fresh priming solution.

At block 334, after the dialysate compartment 222 of the dialyzer 220 is primed with the fresh priming solution, the control device 260 may turn off the valve in the return path of the balancing system 250 to block the return path of the balancing system 250 while the balancing system 250 continues to deliver the fresh priming solution to the dialysate compartment 222 of the dialyzer 220. Blocking of the return path of the balancing system 250 while the venous clamp is opened will cause the fresh priming solution in the dialysate compartment 222 of the dialyzer 220 to cross the membrane of the dialyzer 220 and enter into the venous line 240 via the blood compartment 224 of the dialyzer 220 to flush out the old priming solution in the venous line 240 into the plastic bag 270.

At block 338, after an additional third preset amount of fresh priming solution is delivered into the dialysate compartment 222 of the dialyzer 220 by the balancing system 250, the control device 260 may control the balancing system 250 to stop delivering the fresh priming solution to the dialysate compartment 222 of the dialyzer 220. The third preset amount of fresh priming solution will flush out all the old priming solution in the venous line 240 into the plastic bag 270.

At block 342, after the balancing system 250 is stopped, the control device 260 may turn on the blood pump 235 for a preset period of time to refresh the old priming solution in the arterial line 230 with the fresh priming solution in the venous line 240. Since the extracorporeal circuit is completely filled with the priming solution, the priming solution in the plastic bag 270 will not flow back to the extracorporeal circuit.

Blocks 330-342 may be repeated one or more times as necessary until the priming solution in the extracorporeal circuit is refreshed.

At block 346, after the priming solution in the extracorporeal circuit is refreshed, the control device 260 may turn on the blood pump 235 to circulate the fresh priming solution in the extracorporeal circuit for a preset period of time. During the circulating of the fresh priming solution in the extracorporeal circuit, if it is detected based on the signal from the level detector 248 that there is an excessive air in the venous chamber 244, the control device 260 opens the air vent 247 and closed the venous clamp 246 to remove the excessive air in the venous chamber 244.

After the excessive air in the venous chamber 244 is removed, the blood pump 235 may be turned on by the control device 260 to maintain circulating of the fresh priming solution in the extracorporeal circuit at a programmed blood pump speed until the patient is ready to initiate treatment.

In the first embodiment, only the blood pump, the venous chamber, the venous clamp, the level detector, the balancing system, the Y-connector and the sterilized plastic bag are necessary to realize priming of the dialysis system, and priming of the dialysis system according to the first embodiment is thus applicable in both the basic dialysis machines and the advanced dialysis machines because there are always the blood pump, the venous chamber, the venous clamp and the balancing system in the basic and advanced dialysis machines and the level detector, the Y-connector and the sterilized plastic bag are common and cheap.

Figure 4A is a diagram schematic of a dialysis system according to a second embodiment of the present disclosure. The dialysis system 400 according to the second embodiment differs from the dialysis system 200 according to the first embodiment differ in that in the dialysis system 400, the Y-connector 280 is replaced with a Y-connector 285 as shown in Figure 4B and the plastic bag 270 is replaced with a waste bag 275. The Y-connector 285 is a Y-connector with an additional check valve or an integrated check valve that stops the priming solution in the waste bag 275 to flow back to the extracorporeal circuit. With the Y-connector 285, it may avoid the priming solution in the extracorporeal circuit to be contaminated by the disposed priming solution in the waste bag 275.

Figure 5 is a flowchart of a priming method according to a second embodiment of the present disclosure. The priming method 500 according to the second embodiment differs from the priming method 300 according to the first embodiment in that in the priming method 500, blocks 312, 314 and 318 are replaced with blocks 313 and 316.

At block 313, after the valve in the return path of the balancing system 250 is turned off, the control device 260 may control the balancing system 250 to continue delivering the priming solution into the dialysate compartment 222 of the dialyzer 220, until an additional fourth preset amount of priming solution is delivered into the dialysate compartment 222 by the balancing system 250. The fourth preset amount of priming solution will cause the venous line 240 to be filled with the priming solution and there is no or a little priming solution to be delivered through the venous line 240 into the waste bag 275.

At block 316, after the preset amount of priming solution is delivered into the dialysate compartment 222 by the balancing system 250, the control device 260 may turn on the blood pump 235 to draw the priming solution in the venous line 240 to fill the arterial line 230 and then circulate the priming solution in the extracorporeal circuit while the balancing system 250 continues to deliver the priming solution to the dialysate compartment 222 of the dialyzer 220. The blood pump speed of the blood pump 235 is set such that a volume of the priming solution delivered to the dialysate compartment 222 by the balancing system 250 is considerably sufficient and close to that of the priming solution induced by the blood pump 235 to produce the circulation flow in the extracorporeal circuit. If there is excess priming solution that can't be contained in the extracorporeal circuit, the excess priming solution will be disposed in the waste bag 275.

In the second embodiment, since the blood pump speed of the blood pump 235 is set such that the volume of the priming solution delivered to the dialysate compartment 222 by the balancing system 250 is considerably sufficient and close to that of the priming solution induced by the blood pump 235 to produce the circulation flow in the extracorporeal circuit, smaller amount of priming solution is necessary to realize priming of the dialysis system and only small amount of excessive priming solution will be disposed to the waste bag 275, which may save the priming solution and decrease cost of priming of the dialysis system compared to the first embodiment.

Other Modifications

Those skilled in the art will appreciate that in the above embodiments, at block 310, the control device 260 causes the priming solution in the dialysate compartment 222 to cross the membrane of the dialyzer 220 and enter into the venous line 240 by blocking the return path of the balancing system 250, but the present disclosure is not so limited. In other embodiments of the present disclosure, the control device 260 may utilize any method to cause the priming solution in the dialysate compartment 222 to cross the membrane of the dialyzer 220 and enter into the venous line 240. For example, the control device 260 may control the balancing system 250 such that a rate of the priming solution flowing into the dialysate compartment 222 from the balancing system 250 is larger than a rate of the priming solution flowing out to the balancing system 250 from the dialysate compartment 222.

Those skilled in the art will appreciate that in the above embodiments, the balancing system 250 is used as a supply device to deliver the priming solution to the dialysate compartment 222, but the present disclosure is not so limited. In other embodiments of the present disclosure, any suitable supply device except for the balancing system 250 may also be used to deliver the priming solution to the dialysate compartment 222.

Those skilled in the art will appreciate that in the above embodiments, the dialysis system 200 and 400 include the venous clamp 246 to open or close the venous line 240, but the present disclosure is not so limited. In other embodiments of the present disclosure, the dialysis system 200 and 400 may not include the venous clamp 246.

Those skilled in the art will appreciate that in the above embodiments, the dialysis system 200 and 400 detect whether there is excessive air in the venous chamber 244by using the level detector 248, but the present disclosure is not so limited. In other embodiments of the present disclosure, the dialysis system 200 and 400 may utilize any other suitable manner to detect whether there is the excessive air in the venous chamber 244.

Those skilled in the art will appreciate that in the above embodiments, the priming methods 300 and 500 include block 326 to circulate the priming solution in the extracorporeal circuit at the programmed blood pump speed for the period of time after the excessive air in the venous chamber is removed, but the present disclosure is not so limited. In other embodiments of the present disclosure, the priming methods 300 and 500 may not include block 326.

Those skilled in the art will appreciate that in the above embodiments, the priming methods 300 and 500 include blocks 330-342 to refresh the priming solution in the extracorporeal circuit, but the present disclosure is not so limited. In other embodiments of the present disclosure, the priming methods 300 and 500 may not include blocks 330-342.

Those skilled in the art will appreciate that in the above embodiments, at block 316, the blood pump speed of the blood pump 235 is set such that the volume of the priming solution delivered to the dialysate compartment 222 by the balancing system 250 is considerably sufficient and close to that of the priming solution induced by the blood pump 235 to produce the circulation flow in the extracorporeal circuit, but the present disclosure is not so limited. In other embodiments of the present disclosure, the blood pump speed of the blood pump 235 may also be set such that the volume of the priming solution delivered to the dialysate compartment 222 by the balancing system 250 is less or larger than that of the priming solution induced by the blood pump 235 to produce the circulation flow in the extracorporeal circuit.

Those skilled in the art will appreciate that in the above embodiments, the connector for connecting the arterial line 230 and the venous line 240 to the plastic bag 270 or the waste bag 275 is the Y-connector 280 or 285, but the present disclosure is not so limited. In other embodiments of the present disclosure, the connector for connecting the arterial line 230 and the venous line 240 to the plastic bag 270 or the waste bag 275 may also be any other suitable connector except for the Y-connector.

Those skilled in the art will appreciate that in the above embodiments, the container connected to the arterial line 230 and the venous line 240 via the connector is the sterilized plastic bag 270 or the waste bag 275, but the present disclosure is not so limited. In other embodiments of the present disclosure, the container connected to the arterial line 230 and the venous line 240 via the connector may also be any other suitable except for the sterilized plastic bag 270 and the waste bag 275.

Those skilled in the art will appreciate that in the above embodiments, the excessive air in the venous chamber 244 is removed by the air vent 247 and the venous clamp 246, but the present disclosure is not so limited. In other embodiments of the present disclosure, the excessive air in the venous chamber 244 may be removed by other any suitable manner.

Figure 6 is a flowchart of a priming method according to an embodiment of the present disclosure. The priming method 600 shown in Figure 6 may be implemented by the control device 260 or any other suitable device.

As shown in Figure 6, the priming method 600 may include block 602 for controlling , on the condition that an arterial line is blocked and a venous line is opened, a supply device to deliver a priming solution into a dialysate compartment of a dialyzer, wherein one end of the arterial line with a blood pump and one end of the venous line with a venous chamber are connected to a blood compartment of the dialyzer and the other end of the arterial line and the other end of the venous line are connected to a container via a connector, and the priming solution in the dialysate compartment crosses a membrane of the dialyzer and enters into the venous line.

The priming method 600 may further include block 604 for turning on, after a predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the blood pump to circulate the priming solution in an extracorporeal circuit composed of the arterial line, the blood compartment and the venous line.

In a first aspect, the priming method 600 may further include: detecting whether there is an excessive air in the venous chamber through a level detector; and removing the excessive air in the venous chamber if the detecting is positive, preferably by means of an air vent in communication with the venous chamber and a venous clamp.

In a second aspect, the priming method 600 may further include controlling, after the predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the supply device to stop delivering the priming solution into the dialysate compartment, wherein block 604 may include: turning on, after the supply device is stopped, the blood pump to draw the priming solution in the container to fill the arterial line and then circulate the priming solution in the extracorporeal circuit.

In a third aspect, the connector is a Y-connector and/or the container is a sterilized plastic bag.

In a forth aspect, block 604 may include: turning on the blood pump while the supply device continues to deliver the priming solution into the dialysate compartment.

In a fifth aspect, the connector is configured as a Y-connector with an additional check valve or with an integrated check valve that stops the priming solution in the container to flow back to the extracorporeal circuit; and/or, a volume of the priming solution delivered to the dialysate compartment by the supply device is considerably sufficient and close to that of the priming solution induced by the blood pump to produce the circulation flow in the extracorporeal circuit.

In a sixth aspect, the priming method 600 may further include: circulating the priming solution at a programmed blood pump speed for a preset period of time after the excessive air in the venous chamber is removed or if there is no excessive air in the venous chamber.

In a seventh aspect, the priming method 600 may further include: turning off the blood pump to block the arterial line on the condition that the venous line is opened; controlling the supply device to deliver a fresh priming solution to the dialysate compartment; and, turning on the blood pump after a preset amount of fresh priming solution is delivered into the dialysate compartment by the supply device.

Figure 7 is a schematic diagram of a priming apparatus according to an embodiment of the present disclosure. The priming apparatus 700 shown in Figure 7 may be implemented by software, hardware or a combination of software and hardware. The priming apparatus 700 may be installed in the control device 260 or any other suitable device.

As shown in Figure 7, the priming apparatus 700 may include a controlling module 702 and a turning-on module 704. The controlling module 702 is configured for controlling, on the condition that an arterial line is blocked and a venous line is opened, a supply device to deliver priming solution to a dialysate compartment of a dialyzer, wherein one end of the arterial line with a blood pump and one end of the venous line with a venous chamber are connected to a blood compartment of the dialyzer and the other end of the arterial line and the other end of the venous line are connected to a container via a connector, and the priming solution in the dialysate compartment crosses a membrane of the dialyzer and enters into the venous line. The turning-on module 704 is configured for turning on, after a predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the blood pump to circulate the priming solution in an extracorporeal circuit composed of the arterial line, the blood compartment and the venous line.

In a first aspect, the priming apparatus 700 may further include a detecting module for detecting whether there is an excessive air in the venous chamber through a level detector, and a removing module for removing the excessive air in the venous chamber if the detecting is positive, preferably by means of an air vent in communication with the venous chamber and a venous clamp.

In a second aspect, the priming apparatus 700 may further include a stopping module for controlling, after the predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the supply device to stop delivering the priming solution into the dialysate compartment, wherein the turning-on module 704 is further configured for turning on, after the supply device is stopped, the blood pump to draw the priming solution in the container to fill the arterial line and then circulate the priming solution in the extracorporeal circuit.

In a third aspect, the connector is a Y-connector and/or the container is a sterilized plastic bag.

In a forth aspect, the turning-on module 704 is further configured for turning on the blood pump while the supply device continues to deliver the priming solution into the dialysate compartment.

In a fifth aspect, the connector is configured as a Y-connector with an additional check valve or with an integrated check valve that stops the priming solution in the container to flow back to the extracorporeal circuit; and/or, a volume of the priming solution delivered to the dialysate compartment by the supply device is considerably sufficient and close to that of the priming solution induced by the blood pump to produce the circulation flow in the extracorporeal circuit.

In a sixth aspect, the priming apparatus 700 may further include a circulating module for circulating the priming solution at a programmed blood pump speed for a preset period of time after the excessive air in the venous chamber is removed or if there is no excessive air in the venous chamber.

In a seventh aspect, the priming apparatus 700 may further include a turning-off module for turning off the blood pump to block the arterial line on the condition that the venous line is opened, wherein the controlling module 702 is further configured for controlling the supply device to deliver a fresh priming solution to the dialysate compartment, and the turning-on module 704 is further configured for turning on the blood pump after a preset amount of fresh priming solution is delivered into the dialysate compartment by the supply device.

Figure 8 is a schematic diagram of a control device according to an embodiment of the present disclosure. The control device 260 shown in Figure 8 may include a processor 802 and a memory 804. The memory 804 may store thereon executable instructions that, when executed, cause the processor 802 to implement the priming method 300, 500 or 600.

An embodiment of the present disclosure provides a machine-readable storage medium storing thereon executable instructions that, when executed, cause a processor to implement the priming method 300, 500 or 600.

Figure 9 is a schematic diagram of a dialysis system according to an embodiment of the present disclosure. As shown in Figure 9, the dialysis system 900 may include: a dialyzer 902; an arterial line 904 with a blood pump, wherein one end of the arterial line is connected to a blood compartment of the dialyzer and the other end of the arterial line is connectable to a patient; a venous line 906 with a venous chamber, wherein one end of the venous line is connected to the blood compartment and the other end of the venous line is connectable to the patient; a supply device 908 for delivering priming solution to a dialysate compartment of the dialyzer when priming the dialysis system; and a control device 260.

The previous description of the disclosure is provided to enable any person skilled in the art to make or use the disclosure. Various modifications to the disclosure will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other variations without departing from the spirit or scope of the disclosure. Thus, the disclosure is not intended to be limited to the examples and designs described herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

CLAIMS

1. A priming method, comprising:

controlling, on the condition that an arterial line is blocked and a venous line is opened, a supply device to deliver a priming solution to a dialysate compartment of a dialyzer, wherein one end of the arterial line with a blood pump and one end of the venous line with a venous chamber are connected to a blood compartment of the dialyzer and the other end of the arterial line and the other end of the venous line are connected to a container via a connector, and the priming solution in the dialysate compartment crosses a membrane of the dialyzer and enters into the venous line; and

turning on, after a predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the blood pump to circulate the priming solution in an extracorporeal circuit composed of the arterial line, the blood compartment and the venous line.

2. The priming method of claim 1, further comprising:

detecting whether there is an excessive air in the venous chamber through a level detector; and

removing the excessive air in the venous chamber if the detecting is positive, preferably by means of an air vent in communication with the venous chamber and a venous clamp.

3. The priming method of claim 1, further comprising:

controlling, after the predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the supply device to stop delivering the priming solution into the dialysate compartment,

wherein the turning on the blood pump comprising: turning on, after the supply device is stopped, the blood pump to draw the priming solution in the container to fill the arterial line and then circulate the priming solution in the extracorporeal circuit.

4. The priming method of claim 1 or 3, wherein

the connector is a Y-connector; and/or the container is a sterilized plastic bag.

5. The priming method of claim 1, wherein

the turning on the blood pump comprising: turning on the blood pump while the supply device continues to deliver the priming solution into the dialysate compartment.

6. The priming method of claim 5, wherein

the connector is configured as a Y-connector with an additional check valve or with an integrated check valve that stops the priming solution in the container to flow back to the extracorporeal circuit; and/or

a volume of the priming solution delivered to the dialysate compartment by the supply device is considerably sufficient and close to that of the priming solution induced by the blood pump to produce the circulation flow in the extracorporeal circuit.

7. The priming method of claim 2, further comprising:

circulating the priming solution at a programmed blood pump speed for a preset period of time after the excessive air in the venous chamber is removed or if there is no excessive air in the venous chamber.

8. The priming method of any one of claims 1-7, further comprising:

turning off the blood pump to block the arterial line on the condition that the venous line is opened;

controlling the supply device to deliver a fresh priming solution to the dialysate compartment; and

turning on the blood pump after a preset amount of fresh priming solution is delivered into the dialysate compartment by the supply device .

9. A priming apparatus, comprising:

a controlling module for controlling, on the condition that an arterial line is blocked and a venous line is opened, a supply device to deliver priming solution into a dialysate compartment of a dialyzer, wherein one end of the arterial line with a blood pump and one end of the venous line with a venous chamber are connected to a blood compartment of the dialyzer and the other end of the arterial line and the other end of the venous line are connected to a container via a connector, and the priming solution in the dialysate compartment crosses a membrane of the dialyzer and enters into the venous line; and

a turning-on module for turning on, after a predefined amount of priming solution is delivered into the dialysate compartment by the supply device , the blood pump to circulate the priming solution in an extracorporeal circuit composed of the arterial line, the blood compartment and the venous line.

10. The priming apparatus of claim 9, further comprising:

a detecting module for detecting whether there is an excessive air in the venous chamber through a level detector; and

a removing module for removing the excessive air in the venous chamber if the detecting is positive, preferably by means of an air vent in communication with the venous chamber and a venous clamp.

11. The priming apparatus of claim 9, further comprising:

a stopping module for controlling, after the predefined amount of priming solution is delivered into the dialysate compartment by the supply device, the supply device to stop delivering the priming solution into the dialysate compartment,

wherein the turning-on module is further configured for turning on, after the supply device is stopped, the blood pump to draw the priming solution in the container to fill the arterial line and then circulate the priming solution in the extracorporeal circuit.

12. The priming apparatus of claim 9 or 11, wherein

the connector is a Y-connector; and/or

the container is a sterilized plastic bag.

13. The priming apparatus of claim 9, wherein

the turning-on module is further configured for turning on the blood pump while the supply device continues to deliver the priming solution into the dialysate compartment.

14. The priming apparatus of claim 13, wherein

the connector is configured as a Y-connector with an additional check valve or with an integrated check valve that stops the priming solution in the container to flow back to the extracorporeal circuit; and/or

a volume of the priming solution delivered to the dialysate compartment by the supply device is considerably sufficient and close to that of the priming solution induced by the blood pump to produce the circulation flow in the extracorporeal circuit.

15. The priming apparatus of any of claim 10, further comprising:

a circulating module for circulating the priming solution at a programmed blood pump speed for a preset period of time after the excessive air in the venous chamber is removed or if there is no excessive air in the venous chamber.

16. The priming apparatus of any of claims 9-15, further comprising:

a turning-off module for turning off the blood pump to block the arterial line on the condition that the venous line is opened,

wherein the controlling module is further configured for controlling the supply device to deliver a fresh priming solution to the dialysate compartment, and

the turning-on module is further configured for turning on the blood pump after a preset amount of fresh priming solution is delivered into the dialysate compartment by the supply device.

17. A control device, comprising:

a processor; and

a memory storing thereon executable instructions that, when executed, cause the processor to implement the priming method according to any one of claims 1-8.

18. A machine-readable storage medium storing thereon executable instructions that, when executed, cause a processor to implement the priming method according to any one of claims 1-8.

19. A dialysis system, comprising:

a dialyzer;

an arterial line with a blood pump, wherein one end of the arterial line is connected to a blood compartment of the dialyzer and the other end of the arterial line is connectable to a patient;

a venous line with a venous chamber, wherein one end of the venous line is connected to the blood compartment and the other end of the venous line is connectable to the patient;

a supply device for delivering priming solution to a dialysate compartment of the dialyzer when priming the dialysis system; and

a control device according to claim 17.

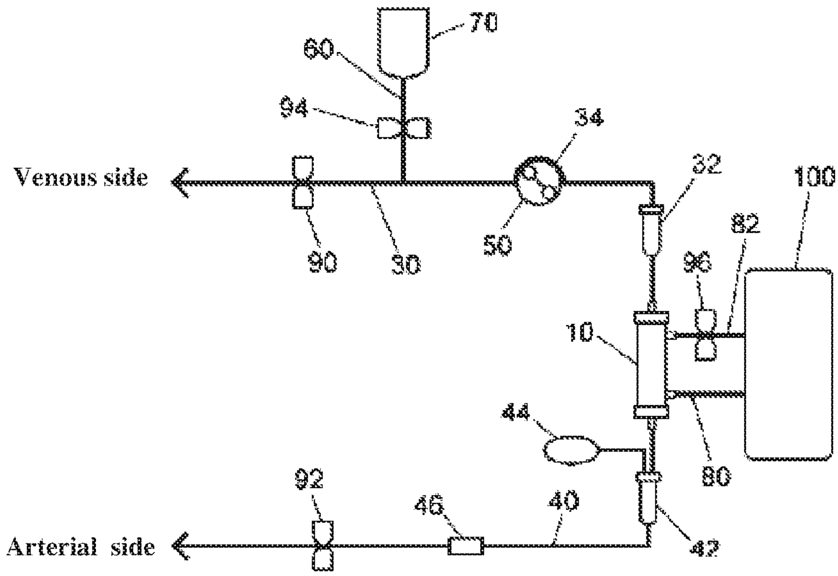

Figure 1A

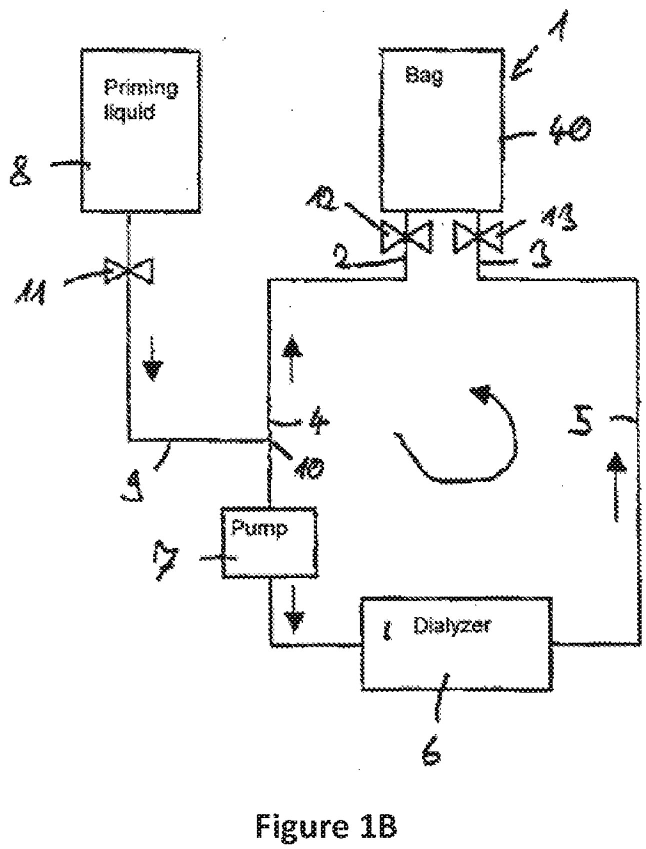

Figure 1B

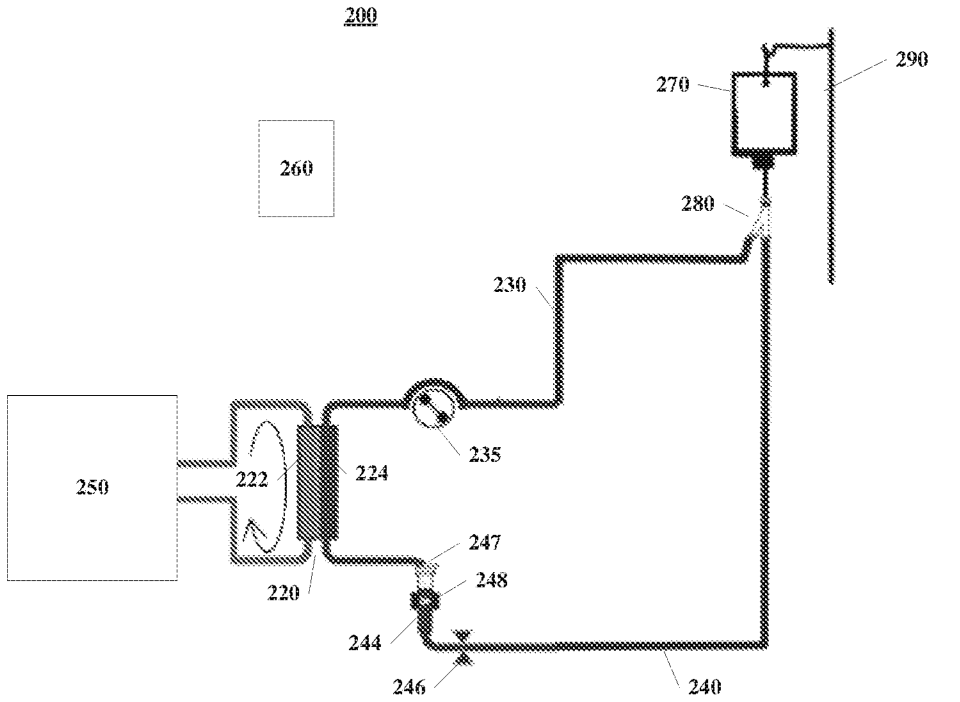

Figure 2A

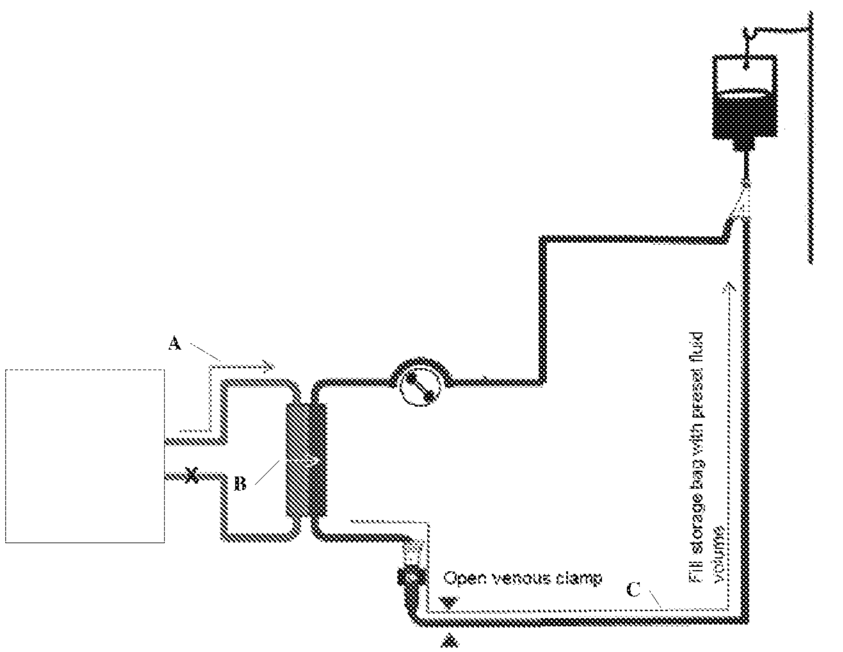

Figure 2B

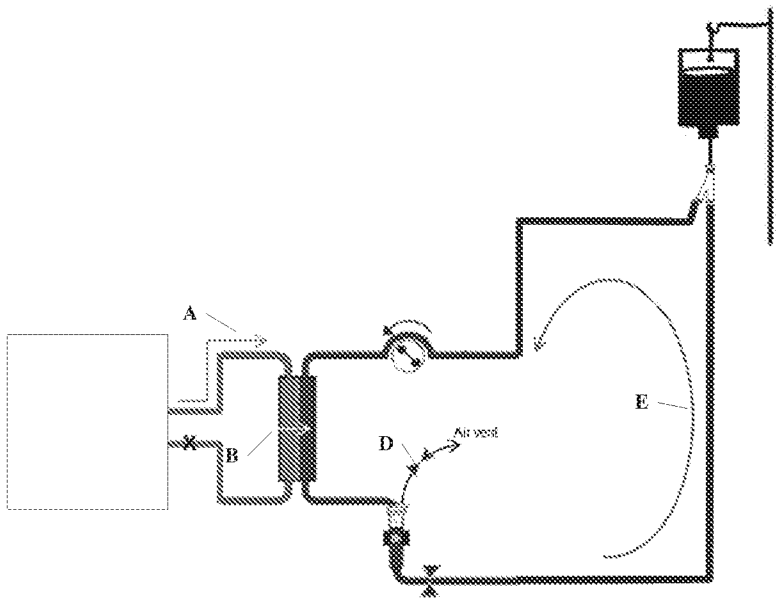

Figure 2C

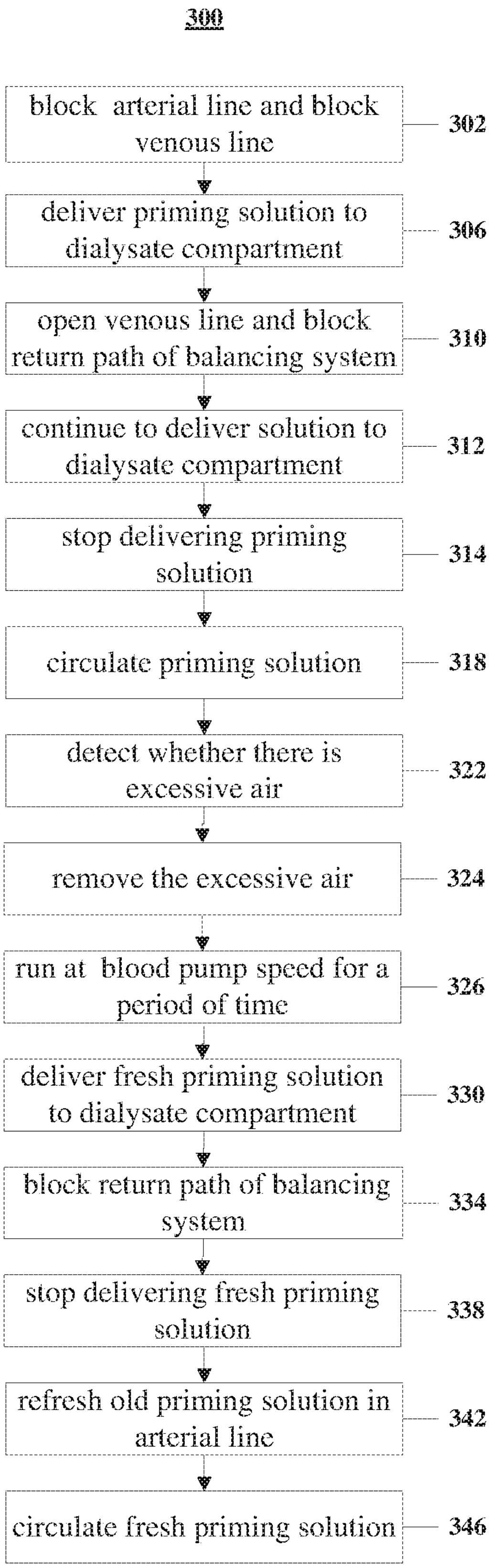
300
block arterial line and block venous line
302
deliver priming solution to dialysate compartment
306
open venous line and block return path of balancing system
310
continue to deliver solution to dialysate compartment
312
stop delivering priming solution
314
circulate priming solution
318
detect whether there is excessive air
322
remove the excessive air
324
run at blood pump speed for a period of time
326
deliver fresh priming solution to dialysate compartment
330
block return path of balancing system
334
stop delivering fresh priming solution
338
refresh old priming solution in arterial line
342
circulate fresh priming solution
346

Figure 3

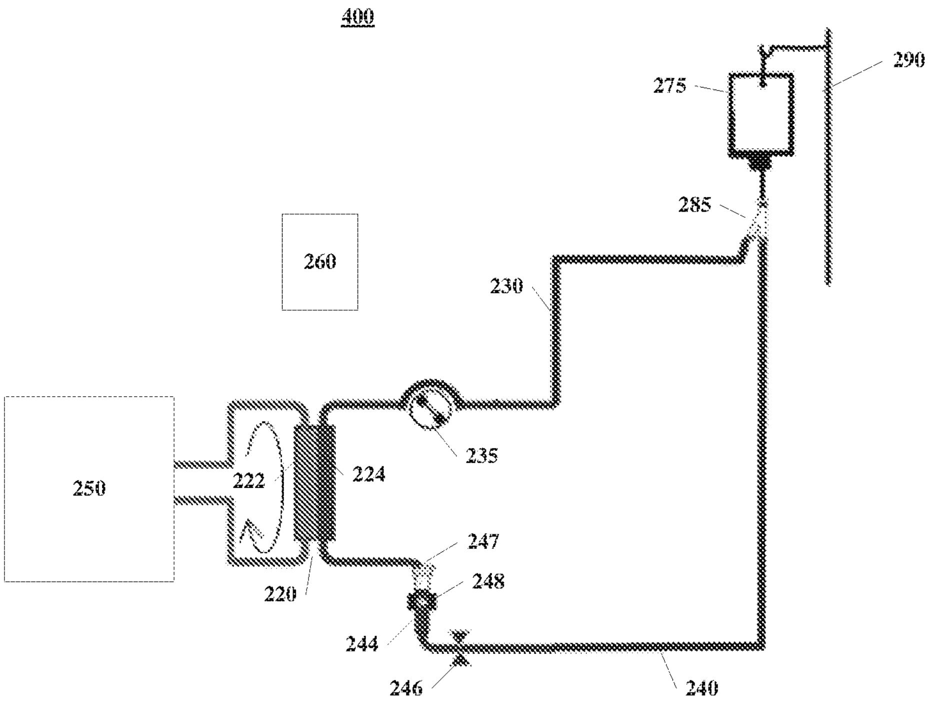

Figure 4A

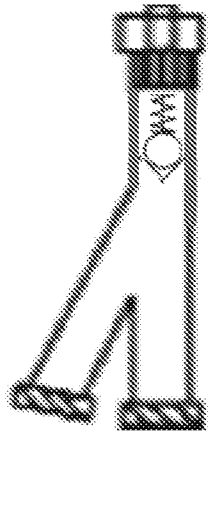

Figure 4B

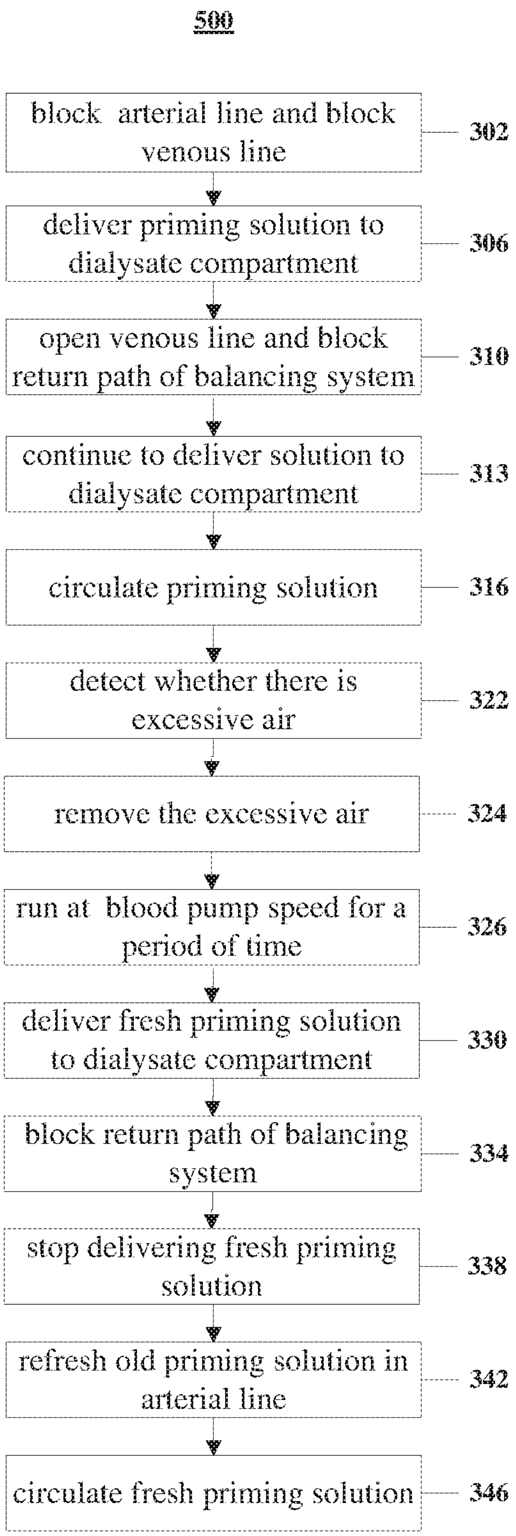
500
block arterial line and block venous line
302
deliver priming solution to dialysate compartment
306
open venous line and block return path of balancing system
310
continue to deliver solution to dialysate compartment
313
circulate priming solution
316
detect whether there is excessive air
322
remove the excessive air
324
run at blood pump speed for a period of time
326
deliver fresh priming solution to dialysate compartment
330
block return path of balancing system
334
stop delivering fresh priming solution
338
refresh old priming solution in arterial line
342
circulate fresh priming solution
346

Figure 5

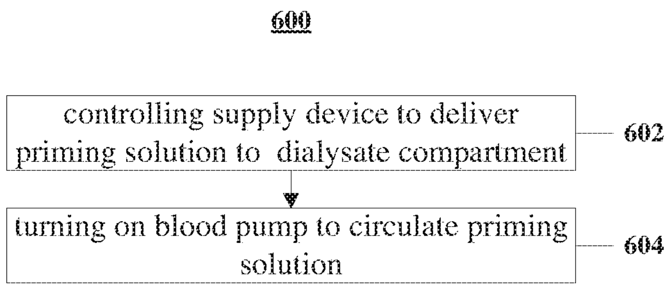

Figure 6

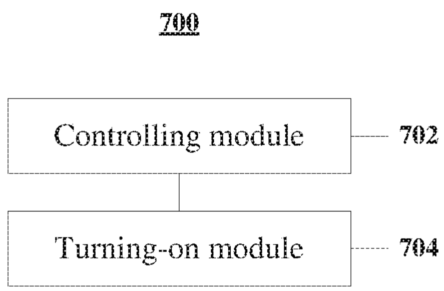

Figure 7

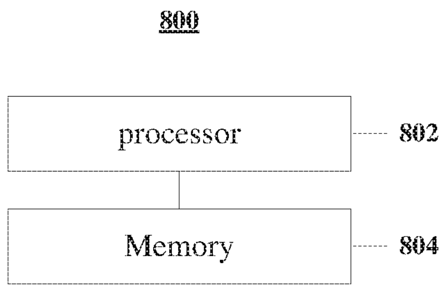

Figure 8

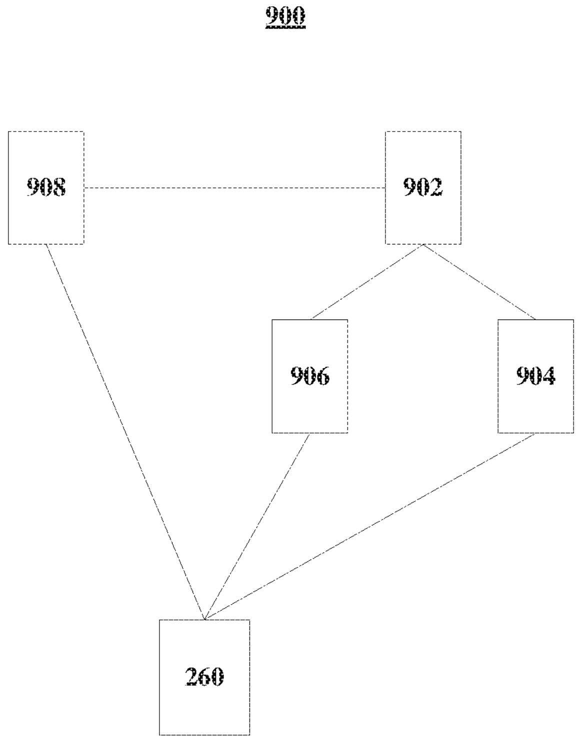

Figure 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/109948

A. CLASSIFICATION OF SUBJECT MATTER

A61M 1/14(2006.01)i; A61M 1/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61M 1/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI,CNPAT,WPI,EPODOC: dialysate, dialysis, arterial, venous, priming, prime, line, block, close, clamp, clean, flush, wash, supply, solution, saline, occlude, rinse, replenish, air, bubble, trap, chamber, level, detector, sensor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015114891 A1 (MEDTRONIC, INC.) 30 April 2015 (2015-04-30) paragraphs [0370], [0430], [0480]-[0484] in the description, figures 1A-1E, 2, 4A-4C, 11	1, 5, 8-9, 13, 16-19
Y	US 2015114891 A1 (MEDTRONIC, INC.) 30 April 2015 (2015-04-30) paragraphs [0370], [0430], [0480]-[0484] in the description, figures 1A-1E, 2, 4A-4C, 11	2, 4, 6-7, 10, 12, 14-15
Y	JP 2014210135 A (KAWASUMI LAB. INC.) 13 November 2014 (2014-11-13) paragraphs [0020], [0026]-[0032 in the description, figure 1	2, 7, 10, 15
Y	CN 101868261 A (FRESENIUS MEDICAL CARE HOLDINGS INC.) 20 October 2010 (2010-10-20) paragraphs [0038]-[0040] in the description, figure 4	4, 6, 12, 14
A	US 2014338756 A1 (BAXTER INTERNATIONAL INC. ET AL.) 20 November 2014 (2014-11-20) the whole document	1-19
A	US 2009124963 A1 (BAXTER INTERNATIONAL INC. ET AL.) 14 May 2009 (2009-05-14) the whole document	1-19

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 June 2019	**02 July 2019**

Name and mailing address of the ISA/CN	Authorized officer
National Intellectual Property Administration, PRC **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**WANG,Jingyang**
Facsimile No. **(86-10)62019451**	Telephone No. **86-(10)-53962396**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/109948

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				WO	2014121157	A1	07 August 2014
				EP	2950841	A1	09 December 2015
				CN	104968376	B	15 March 2019
				AU	2014212129	B2	19 April 2018
				EP	2950841	B1	28 November 2018
				AU	2018202721	A1	10 May 2018
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				EP	2205295	A1	14 July 2010
				US	2018036472	A1	08 February 2018
				US	2009088675	A1	02 April 2009
				WO	2009064540	A2	22 May 2009
US	2009124963	A1	14 May 2009	US	8992463	B2	31 March 2015
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				EP	2612684	A2	10 July 2013
				US	2015258263	A1	17 September 2015
				CA	2704411	A1	14 May 2009
				EP	2219703	A1	25 August 2010
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/109948

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
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		CA	2219820	A1	19 December 1996
		CA	2219820	C	15 August 2006
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		EP	0831945	B1	11 May 2005
		JP	2007105489	A	26 April 2007
		ES	2238692	T3	01 September 2005
		JP	3951030	B2	01 August 2007