HEMODIALYSIS SYSTEM

FIELD OF INVENTION

The present invention generally relates to hemodialysis and similar dialysis systems, e.g., systems able to treat blood or other bodily fluids extracorporeally.

BACKGROUND

Many factors make hemodialysis inefficient, difficult, and expensive. These factors include the complexity of hemodialysis, the safety concerns related to hemodialysis, and the very large amount of dialysate needed for hemodialysis. Moreover, hemodialysis is typically performed in a dialysis center requiring skilled technicians. Therefore any increase in the ease and efficiency of the dialysis process could have an impact on treatment cost or patient outcome.

SUMMARY OF INVENTION

According to a first aspect of the present invention, there is provided an occlusion assembly for occluding at least one pair of collapsible tubes of a medical infusion device, comprising: for each pair of collapsible tubes, a first occluding member and a second occluding member, the first occluding member positioned adjacent to a first collapsible tube of the pair and the second occluding member positioned adjacent to a second collapsible tube of the pair, when the tubes are installed in the occlusion assembly for operation, the first occluding member and the second occluding member being further positioned adjacent from each other such that a space is defined between the first occluding member and the second occluding member, the space being on an opposite side of each occluding member than is the collapsible tube to which it is adjacent; a spreader positioned within the space and movable within the space from a first position to a second position, wherein movement from the first position to the second position causes the spreader to force at least a portion of the first and second occluding members to move apart from each other to increase the size of the space and force a tube-contacting portion of each occluding member against the collapsible tube to which it is adjacent to occlude the collapsible tube; and at least one actuator constructed and positioned to move the spreader between the first position and the second position.

According to a second aspect of the present invention, there is provided a method of operating an occlusion assembly for occluding at least one pair of collapsible tubes of a medical infusion device, comprising: moving a spreader of the occlusion assembly from a first position to a second position, wherein the spreader is positioned within a space defined between a first occluding member and a second occluding member, to cause the spreader to force at least a portion of the first and second occluding members to move apart from each other to increase the size of the space and force a tube-contacting portion of each occluding member against a collapsible tube to which it is adjacent to occlude the collapsible tube.

Embodiments of the invention generally relate to hemodialysis and similar dialysis systems. Illustrative embodiments described herein involve, in some cases, interrelated products, alternative solutions to a particular problem, and/or a plurality of different uses of one or more systems and/or articles. Although the various systems and methods described herein are described in relation to hemodialysis, it should be understood that the various systems and method described herein are applicable to other dialysis systems and/or in any extracorporeal system able to treat blood or other bodily fluids, such as hemofiltration, hemodiafiltration, etc.

In one embodiment of the invention, a drain cassette for a dialysis unit includes a venous connection port for connection to, and fluid communication with, a venous blood line connector, an arterial connection port for connection to, and fluid communication with, an arterial blood line connector, a fluid channel fluidly connecting the venous connection port and the arterial connection port, a drain outlet port in fluid communication with the fluid channel and arranged to removably couple with a drain connector on an exposed panel of the dialysis unit, and a valve arranged to control flow in the fluid channel. The valve may be arranged to control in the fluid channel to either controllably open and close fluid communication in the fluid channel between the drain outlet port and the venous connection port, or to controllably open and close fluid

and venous connection ports fluidly connected to the fluid channel at ends of the U shape, and the drain outlet port fluidly connected to the fluid channel at a central bend of the U shape.

One or more sensors may be included to detect characteristics of fluid in the fluid channel or elsewhere in the drain cassette. For example, a conductivity sensor may be arranged to detect a conductivity of fluid in the fluid channel, and a temperature sensor may be arranged to detect a temperature of fluid in the fluid channel. The one or more sensors may be coupled to an electrical connector arranged to electrically connect the one or more sensors to a corresponding electrical connector on the exposed panel. In one embodiment, the electrical connector and the drain outlet port are arranged to simultaneously couple with a corresponding electrical connector and drain connector on the exposed panel of the dialysis unit in a single connection operation. In some arrangements, a pneumatic control port coupled to the valve may be arranged to removably mate with a control port on the exposed panel, and to simultaneously couple with the corresponding control port in the same single connection operation used to connect the drain port and electrical connector.

The valve may be arranged so that the drain outlet port is in permanently open fluid communication with the arterial connection port, and the valve may controllably open and close fluid communication in the fluid channel between the drain outlet port and the venous connection port. Alternately, the drain outlet port may be in permanently open fluid communication with the venous connection port, and the valve may be arranged to controllably open and close fluid communication in the fluid channel between the drain outlet port and the arterial connection port.

In another embodiment of the invention, a blood circuit assembly and a drain cassette may be engageable with an exposed panel of a dialysis unit for operation in a dialysis treatment, and may be removable from the exposed panel for replacement without the use of tools. Such an arrangement may allow for easy replacement of all blood-contacting components of a dialysis unit so that the dialysis unit can be used for multiple, different patients (e.g., in a clinical setting) while minimizing risk of a prior patient's blood borne materials from coming into contact with a subsequent patient's treatment components. For example, the blood circuit assembly may include a pair of pneumatic pumps for circulating blood received from a patient through a circuit including a dialyzer

In another embodiment of the invention, a blood circuit assembly for a dialysis unit includes a pair of pneumatic pumps for circulating blood received from a patient through a circuit including a dialyzer unit and returning the blood to the patient, an air trap arranged to remove air from blood circulating in the circuit, a pair of dialyzer connections arranged to connect to the inlet and outlet of a dialyzer unit, a pair of blood line connectors, including an arterial blood line connector for receiving blood from the patient and providing blood to the pneumatic pumps and a venous blood line connector for returning blood to the patient, and flexible tubing fluidly connecting the pumps, the air trap, the dialyzer connections and the blood line connectors. The pneumatic pumps may have pneumatic control ports arranged for alignment and mating with corresponding ports located on an exposed panel of the dialysis unit by pushing the control ports into engagement with the corresponding ports with mounting of the blood circuit assembly to the exposed panel.

Also, the pumps may be defined, at least in part, by a single unitary member that additionally defines a plurality of routing channels for at least a portion of the flexible tubing. In one embodiment, the single unitary member or other organizing tray configuration defines an air trap cavity that receives the air trap. In some arrangements, the inlet of the air trap is supported by the air trap cavity or other support at a position above an outlet of the air trap when the blood circuit assembly is mounted to a dialysis unit. This configuration may make removal of air from the blood lines more effective.

In another embodiment, the single unitary member may define the pneumatic control ports for the pumps, a concave chamber portion for the pumps, a chamber portion of a plurality of valves used to control flow through the pumps, routing channels for flexible tubing to position the tubing for engagement with an occluder when the assembly is mounted to the dialysis unit, and/or other features. For example, the organizing tray may include circuit tube engagement members having a hole through which a respective circuit tube passes that engage with the tube to allow the circuit tube to be pulled and stretched for engagement with an occluder of the dialysis unit. Having a single part define multiple portions of the blood circuit assembly and/or to accurately route flexible tubing may make assembly of the blood circuit assembly easier and more effective, e.g., by ensuring that various components are properly positioned on the panel of the dialysis unit.

In another embodiment, the flexible tubing may connect components as follows: the arterial blood line connector may be connected to an inlet for the pump cassette, an outlet for the pump cassette may be connected to a dialyzer inlet connector, a dialyzer outlet connector may be connected to an inlet of the air trap, and an outlet of the air trap may be connected to the venous blood line connector.

In some embodiments, the blood circuit assembly may include an anticoagulant connection for engaging with an anticoagulant source and providing anticoagulant into the circuit. For example, a pump for pumping anticoagulant from the anticoagulant source to the circuit may be included, e.g., as part of a pump cassette. The anticoagulant connection may include a vial holder and a spike, and the anticoagulant source may be a vial of heparin.

In another embodiment of the invention, a blood circuit assembly engagement device for a dialysis unit includes an actuator, movable between a retention position and an ejection position, mounted to a panel of the dialysis unit adjacent a plurality of control ports, a retainer element coupled to the actuator and arranged, with the actuator in the retention position, to retain a blood circuit assembly mounted to the panel of the dialysis unit on the panel, and arranged, with the actuator in the ejection position, to release the blood circuit assembly for removal from the panel of the dialysis unit, and an ejector element coupled to the actuator and arranged, with the actuator moved from the retention position to the ejection position, to urge the blood circuit assembly away from the panel. Such an arrangement may make mounting, retention and removal of a blood circuit assembly with respect to a dialysis unit more accurate and effective. For example, if the retainer element is not positioned in the retention position with a blood circuit assembly mounted to the panel, a user can easily verify that the assembly is not properly engaged with the panel. The actuator can then be used to eject the assembly, allowing replacement of the assembly on the panel.

In one embodiment, the actuator is pivotally mounted to the panel, and the retainer element is fixed to the actuator. The ejector element may be pivotable between an inactive position and an ejection position, and pivoted based on movement of the actuator. For example, the actuator may be arranged to be moved from the retention position and the ejection position by a user's thumb. In one arrangement, first and second blood circuit assembly engagement devices are provided on the panel, with the

example, to prevent a release of occlusion force on the tubing when the door is not in a closed position and/or convenience features, for example a retainer mechanism to hold the tube occluder in a non-occluding position when the door is open with the tube occluder in the non-occluding position.

In one embodiment, a variety of occlusion assemblies for occluding at least one collapsible tube of a medical infusion device are described. In certain embodiments, the occlusion assembly is configured for occluding at least one pair of collapsible tubes and comprises, for each pair of collapsible tubes, a first occluding member and a second occluding member, the first occluding member positioned adjacent to a first collapsible tube of the pair and the second occluding member positioned adjacent to a second collapsible to the pair, when the tubes are installed in the occlusion assembly for operation. The first occluding member and the second occluding member are further positioned adjacent from each other such that a space is defined between them. These space is on an opposite side of each occluding member then is the collapsible tubes to which it is adjacent. The occlusion assembly further comprises a spreader positioned within the space between the occluding members and movable from a first position to a second position, wherein movement from the first position to the second position causes the spreader to force at least a portion of the first and second occluding members to move apart from each other to increase the size of the space between them and forced a tube-contacting portion of each occluding member against the collapsible tube to which it is adjacent to occlude the collapsible tube. The occlusion assembly further comprises at least one actuator constructed and positioned to move the spreader between the first and second positions.

In certain embodiments the occlusion assembly is configured for occluding at least one collapsible tube and comprises a frame comprising a tubing guide configured for positioning the collapsible tube, a tubing occluder mounted to the frame and comprising an occluding member constructed and positioned to controllably occlude or release occlusion of the collapsible tube, a door hingeably mounted to the frame and positioned to cover at least a portion of the collapsible tube and tubing occluder when in a closed position and to provide user access to the collapsible tube when in an open position, and a switch configured and positioned to detect when the door is in a closed

position and to permit operation of the tubing occluder to release occlusion of the collapsible tube only when the door is in the closed position.

In certain embodiments and occlusion assembly for collapsing at least one collapsible tube comprises a tubing occluder comprising an occluding member constructed and positioned to controllably occlude or release occlusion of the collapsible tube, and automatic actuator operatively coupled to the tubing occluder to cause essentially linear motion of at least a portion of the tubing occluder to cause the occluding member to move from an occluding position to a non-occluding position, and an override mechanism operatively coupled to the tubing occluder to cause essentially linear motion of at least a portion of the tubing occluder to cause the occluding member to move from an occluding position to a non-occluding position upon manual operation of the override mechanism by a user.

In certain embodiments, and occlusion assembly for occluding at least one collapsible tube comprises a frame comprising a tubing guide configured for positioning the collapsible tube, a tubing occluder mounted to the frame and comprising an occluding member constructed and positioned to controllably occlude or release occlusion of the collapsible tube, a door hindgeably mounted to the frame and positioned to cover at least a portion of the collapsible tube and tubing occluder when in a closed position and to provide user access to the collapsible tube when in an open position, and a retainer mechanism engaged by the door when the door is in the closed position and configured to permit operation of the tubing occluder to occlude or release occlusion of the collapsible tube when the door is in the closed position and configured to engage and retain the tubing occluder in a non-occluding configuration when the door is opened while the tubing occluder is positioned in the non-occluding configuration.

In another embodiment a method of operating an occlusion assembly for occluding at least one pair of collapsible tubes of a medical infusion devices disclosed. In one embodiment, the method involves moving a spreader of the occlusion assembly from a first position to a second position, wherein the spreader is positioned within a space defined between a first occluding member and a second occluding member to cause the spreader to force at least a portion of the first and second occluding members to move apart from each other to increase the size of the space between them and force a tube-

contacting portion of each occluding member against a collapsible tube to which it is adjacent to occlude the collapsible tube.

In another embodiment of the invention, an enclosure for containing a portable hemodialysis unit is provided, where the hemodialysis unit includes suitable components for performing hemodialysis including a dialyzer, one or more pumps to circulate blood through the dialyzer, a source of dialysate, and one or more pumps to circulate the dialysate through the dialyzer. The enclosure may include a housing that supports the components of the hemodialysis unit and has a front panel at which blood circuit connections and dialysate fluidic connections are located. For example, the front panel may support blood line connections for patient blood access, connections for a reagent supply, dialyzer connections for both blood flow and dialysate, etc. Thus, in one embodiment, an operator may complete all necessary fluid circuit connections for the blood circuit and reagent supply at the housing front panel. The enclosure may also include a pair of vertical, side-by-side doors hingedly mounted to the housing at opposite sides of the front panel so that the doors are movable between open and closed positions. With the doors in an open position, an operator may have access to the blood circuit connections and dialysate fluidic connections. Also, with the doors in the closed position, access to the patient access and dialysate fluidic connections may be blocked, and the doors may allow for the retention of heat in the housing suitable for disinfection during a disinfection cycle. For example, at least one of the doors may include a seal to resist air exchange between an interior and an exterior of housing when the doors are in the closed position to help retain heat and/or help resist entry of dust, dirt or other contaminants.

In one embodiment, each of the vertical, side-by-side doors is mounted to the housing via a hinge plate that is pivotally mounted to the door at a first end, and is pivotally mounted to the housing at a second end opposite the first end. Thus, the doors may be positionable at two open positions, e.g., a first open position in which blood circuit connections and dialysate fluidic connections are exposed and the hinge plate is adjacent the housing, and a second open position in which the hinge plate is positioned away from the housing. One or more retainer members may be included to maintain the doors in an open position relative to a corresponding hinge plate. For example, the retainer member may include at least one magnet attached to the door or the hinge plate

In another embodiment, the enclosure may include an electronics section that is separated and insulated from a disinfection section that is heated to disinfect components of the hemodialysis unit. For example, the disinfection section may include all of the liquid circuit components, such as valves, pumps, conduits, etc., of the various portions of the dialysis unit. The electronics section may include motors, computers or other data processing devices, computer memory, and/or other temperature sensitive electronics or other components. By isolating the electronics section from the disinfection section (at least to some degree), components in the electronics section may be spared exposure to the heat or other environmental conditions in the disinfection section whether during a disinfection operation or otherwise.

In another embodiment of the invention, a portable hemodialysis system may be arranged so that power for the fluid circuit pumps of a dialysis unit may be provided by a modular power unit, e.g., a unit that can be selectively connected to or disconnected from the dialysis unit. As a result, failure of a power unit need not necessarily disable the entire dialysis system. Instead, the power unit may be replaced with another power unit, allowing for treatment to continue. For example, a modular assembly for a portable hemodialysis system may include a dialysis unit, e.g., including a housing that contains suitable components for performing hemodialysis, such as a dialyzer, one or more pumps to circulate blood through the dialyzer, a source of dialysate, and one or more pumps to circulate the dialysate through the dialyzer. The housing may have a front panel at which blood circuit connections and dialysate fluidic connections are located, e.g., where an operator may make patient blood access connections, connect a reagent supply, and/or connect a dialyzer. The modular assembly may also include a power unit having a housing that contains suitable components for providing operating power to the pumps of the dialysis unit. The power unit may be selectively connected to the dialysis unit and provide power to the dialysis unit for the pumps when connected to the dialysis unit, but may be incapable of providing power to the dialysis unit when disconnected from the dialysis unit. The power unit may be selectively connected to and disconnected from the dialysis unit by operation of a single handle, e.g., an operator may turn or otherwise operate a single handle to disconnect the power unit from the dialysis unit. In one embodiment, the dialysis unit and the power unit are sized and weighted to each be carried by hand by a human.

In one embodiment, the pumps of the dialysis unit are pneumatic pumps and the power unit provides pneumatic power to the dialysis unit. For example, the power unit may provide air pressure and/or vacuum to the dialysis unit to power the pumps. The power unit may include one or more air pressure pumps and/or air vacuum pumps, and the dialysis unit may include a plurality of valves to control application of pneumatic power to the pumps. To aid with use of the hemodialysis system in the home, the power unit and dialysis unit electrical power requirements may be provided by standard residential electrical power, e.g., approximately 110V, 15amp electrical power. The dialysis unit may provide electrical power to the power unit, and the power unit may use the electrical power to generate operating power for the pumps.

In another embodiment of the invention, a blood circuit assembly for a dialysis unit may be arranged to allow the replacement of most or all blood circuit components in a single operation. For example, the blood circuit assembly may include an organizing tray, a pair of pneumatic pumps mounted to the organizing tray for circulating blood received from a patient through a circuit including a dialyzer unit and returned to the patient, an air trap mounted to the organizing tray arranged to remove air from blood circulating in the circuit, a pair of dialyzer connections arranged to connect to the inlet and outlet of a dialyzer unit, and a pair of blood line connectors, one inlet blood line connector for receiving blood from the patient and providing blood to the pneumatic pumps and the other outlet blood line connector for returning blood to the patient.

In one embodiment, an anticoagulant connection is provided for engaging with an anticoagulant source and providing anticoagulant into the blood circuit. For example, the anticoagulant connection may include a pump for pumping anticoagulant from the anticoagulant source, such as heparin from a vial of heparin, to the circuit. The anticoagulant connection may include a vial holder arranged to hold two or more differently sized vials, and a spike to pierce the vial. In one embodiment, the pair of pneumatic pumps, the anticoagulant connection, and the anticoagulant pump are part of a pump cassette.

In another embodiment, the blood circuit assembly may be selectively mounted to and removed from a dialysis unit. To aid in handling of the blood circuit assembly, the organizing tray may include a pair of handles arranged for gripping by a user. The organizing tray may also include openings adjacent each of the handles for receiving

retaining tabs on a dialysis unit that engage with the blood circuit assembly and retain the blood circuit assembly on the dialysis unit.

In one embodiment, the inlet blood line connector is connected to an inlet for the pump cassette, an outlet for the pump cassette is connected to a dialyzer inlet connector, a dialyzer outlet connector is connected to an inlet of the air trap, and an outlet of the air trap is connected to the outlet blood line connector. The inlet of the air trap may be located above the outlet of the air trap when the blood circuit assembly is mounted to a dialysis unit, e.g., to aid in trapping of air circulating in the circuit during treatment. The blood line connectors may be arranged for a threaded luer-type connection to a patient access, as well as be arranged for a press-in type connection to the dialysis unit. Such an arrangement may make it easier for an operator to connect the blood line connectors to the dialysis unit after treatment (e.g., for later disinfection and/or priming of the blood circuit) while allowing the connectors to engage with standard luer-type connectors at a patient blood access.

In one embodiment, the organizing tray may include circuit tube engagement members having a hole or slot through which a respective circuit tube passes. The engagement members may engage with the respective circuit tube to allow the circuit tube to be pulled and stretched for engagement with an occluder of the dialysis unit. For example, the circuit tubes of the blood circuit assembly may include silicone tubing that has to be stretched (and thereby reduced in diameter) to engage with an occluder. The circuit tube engagement members may resist the pull of an operator on the tubes, allowing the tubes to be stretched and placed in engagement with the occluder.

In another embodiment of the invention, a method for replacing a blood circuit assembly of a dialysis unit includes grasping a pair of handles on an organizing tray of a blood circuit assembly that is mounted to a dialysis unit, disengaging locking tabs of the dialysis unit from the blood circuit assembly to free the blood circuit assembly from the dialysis unit, and pulling on the handles on the organizing tray of the blood circuit assembly to remove the blood circuit assembly from the dialysis unit. Disengagement of the locking tabs may be performed by flexing the locking tabs away from each other such that each locking tab is moved toward a nearest one of the handles. After removal of the blood circuit assembly, a replacement blood circuit assembly may be provided, openings in the organizing tray of the replacement blood circuit assembly may be aligned

with the locking tabs so that each locking tab is received into a respective opening, and the organizing tray may be pushed relative to the dialysis unit such that the locking tabs engage with the replacement blood circuit assembly to mount the replacement blood circuit assembly to the dialysis unit. Mounting the replacement blood circuit assembly may also involve connecting control ports on the dialysis unit to mating ports on the assembly so that fluid control signals may be provided for pumps and valves of the blood circuit assembly. Other blood circuit connections may be made, such as inlet and outlet connections for the dialyzer, and the blood line connectors may be connected to receive dialysate into the blood circuit.

In another embodiment of the invention, an air trap for a blood circuit in a dialysis unit includes a blood inlet supply line, a blood outlet supply line, and a container having an approximately spherical internal wall, an inlet at a top end of the container connected to the blood inlet supply line, and an outlet at a bottom end of the container connected to the blood outlet supply line. The inlet may be offset from a vertical axis of the approximately spherical internal wall such that blood entering the container through the inlet is directed to flow in around the approximately spherical wall in a spiral-like path. Such flow in the container may help to remove air bubbles from the blood as it flows from the inlet to the outlet, with any removed air remaining near the top of the container. The inlet port may be arranged to introduce blood into the container in a direction that is approximately tangential to the approximately spherical inner wall of the container and/or in a direction that is approximately perpendicular to the vertical axis of the container.

In one embodiment, a self-sealing port may be located at a top of the container, e.g., in the form of a split septum that is arranged to permit introduction of fluid into, and withdrawal of liquid from, the container by inserting a needleless device through the split septum. The self-sealing port may be arranged to be self-cleaning when disinfection liquid is circulated through the container, e.g., the port may be suitably exposed to flowing disinfection liquid to remove debris and/or heat material on the port to achieve desired disinfection.

In another embodiment of the invention, a tube securing arrangement of a blood circuit assembly includes a organizing tray that supports components of a blood circuit assembly and includes a pair of tube engagement members each having a hole, a pair of

patient inlet and outlet lines arranged to connect with patient access points for receiving liquid from and/or providing liquid to the patient, and a pair of stops on the patient inlet and outlet lines, respectively. The patient inlet and outlet lines may each pass through a hole of a respective tube engagement member so that the stop engages with the tube engagement member. With this arrangement, the tube engagement members may resist pulling and stretching of the inlet and outlet lines when engaging the lines with an occluder. The tube engagement members may be flexible to allow a user to press inwardly on the engagement member and seat the respective inlet or outlet line in the occluder, yet resist downward pulling of the line.

In another embodiment of the invention, a hemodialysis system includes a dialyzer mount arranged to support a plurality of differently sized and/or shaped dialyzer units and to accommodate different distances between dialysate connections on the dialyzer units. The dialyzer mount, which may be located on a front panel of the dialysis unit, may include a pair of flange portions that are each arranged to engage with a respective dialysate quick-connect fitting connected to a dialysate port of the dialyzer. Each flange portion may be arranged to engage with a groove on the quick connect fitting that is located between a portion of the base of the quick connect fitting and a slide element of the quick connect fitting. For example, the dialyzer mount may include a pair of keyhole features with each keyhole feature having an upper insertion area sized to receive a portion of the base of the quick-connect fitting inserted into the upper insertion area, and a lower flanged portion having a width that is smaller than an overall a width of the base of the quick-connect fitting and that engages with a groove on the quick connect fitting. The lower flanged portion may include a pair of opposite flanges that engage with the groove and allow the quick-connect fitting to slide along the flanges.

In one embodiment, the bottom keyhole feature may include an adjustable support that is moveable in a vertical direction. For example, the adjustable support may be movable along the opposed flanges. Thus, the adjustable support may be fixable in a plurality of different positions on the flanges to support the weight of the dialyzer. In one arrangement, the adjustable support includes a "U" shaped member and at least one thumb screw that may be tightened to fix the "U" shaped member in place. .

In another embodiment of the invention, a blood line connector for a blood circuit of a hemodialysis unit may have the ability to make two different types of fluid tight

connections, e.g., a screw-type connection with a luer connector at a patient access and a press-in type connection with a dialysate circuit of the hemodialysis unit. For example, the blood line connector may include a tube connection end arranged to sealingly engage with a blood circuit tube, and a patient access connection end with a frustoconical member having an internally threaded portion arranged to engage with an externally threaded patient access, and a pair of locking arms extending rearwardly from the frustoconical member. The locking arms may each have a finger depression portion and a barbed portion, and may be arranged to engage with a mating connector on the dialysis unit at the barbed portions to lock the frustoconical member in sealing engagement with the mating connector when making a press-in type connection. The barbed portions may disengage from the mating connector when the finger depression portions are urged toward each other. In one embodiment, the patient access connection end may include a central tube extending from the center of the frustoconical member. The internally threaded portion of the frustoconical member and the central tube may be arranged to mate with a female luer-type patient access connector or any other suitable screw-type connection.

In another embodiment of the invention, a method for operating a dialysis unit includes connecting blood line connectors of arterial and venous blood lines for a dialysis unit to patient access connectors in communication with a patient blood system. In one embodiment, the patient access connectors may require a corresponding blood line connector to establish a threaded engagement with the patient access connector, thereby forming a luer or screw-type connection between the blood line connectors and the patient access connectors. The dialysis unit may be operated to withdraw blood from a patient access connector and into an arterial blood line, subject the withdrawn blood to a dialysis process to produce treated blood, and return the treated blood to the patient via the venous blood line and the other patient access connector. Thereafter, the blood line connectors may be disconnected from the patient access connectors by unscrewing the blood line connectors from a corresponding patient access connector, and the blood line connectors may be connected to a directing circuit of the dialysis unit. The blood line connectors may be connected to the directing circuit by a press-in connection with a corresponding connection point on the dialysis unit, e.g., by pushing the blood line connectors into the connection points to establish the press-in connection.

In another embodiment of the invention, a reagent supply arrangement for a hemodialysis system may be arranged to provide two or more reagent materials for use in preparing a dialysate and may include a connector arranged to help prevent the connection of a reagent material to the wrong port. For example, the reagent supply may include an E-prong connector having three parallel prongs with two outer prongs arranged in a common plane and a center prong arranged above the common plane, a first supply line for a first reagent connected in fluid communication with one of the outer prongs, a second supply line for a second reagent connected in fluid communication with the other of the outer prongs, a liquid line connected in fluid communication with the center prong, and a container for housing the first reagent having an inlet connected to the liquid line and an outlet connected to the first supply line for the first reagent. The E-prong connector may help prevent the improper connection of the first and second supply lines to the dialysis unit, e.g., because the central prong being located out of the plane of the two outer prongs ensure connection of the E-prong connector in only one way to the dialysis unit.

In one embodiment, the container includes a bicarbonate material suitable for use in generating a dialysate for the hemodialysis system. The liquid line may be a water supply line that provides water to the container, allowing the water to mix with the bicarbonate (which may be in powder or other solid form) and flow to the first supply line. The second supply line may be an acid supply line that includes a connector and provides acid material to the E-prong connector. The reagent supply may also include an acid bag spike that is removably engaged with the connector of the acid supply line. The acid bag spike may include a spike member and a pair of spring clips at an end of the acid bag spike opposite the connector of the acid supply line, allowing the acid bag spike to be fluidly connected with an acid bag or other acid source.

In another embodiment of the invention, a method for operating a hemodialysis system includes providing a dialysis unit having an enclosure containing suitable components for performing hemodialysis including a dialyzer, one or more pumps to circulate blood through the dialyzer, a source of dialysate, and one or more pumps to circulate the dialysate through the dialyzer. The enclosure may include a housing that supports the components and has a front panel at which blood circuit connections and dialysate fluidic connections are made. A reagent supply may be provided including an E-prong