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(54) **URINE OUTPUT SENSING WITHOUT USE OF AN INDWELLING CATHETER, AND ASSOCIATED SYSTEMS, DEVICES, AND METHODS**

(71) Applicant: **REPRIEVE CARDIOVASCULAR, INC.**, Milford, MA (US)

(72) Inventors: **Andrew V. HALPERT**, Brookline, MA (US); **Antony Jonathan FIELDS**, San Francisco, CA (US); **Eric CONLEY**, York, ME (US); **Mark Richard PACYNA**, Edina, MN (US); **Megha SHAH**, Milford, MA (US); **Jeffrey TESTANI**, New Haven, CT (US)

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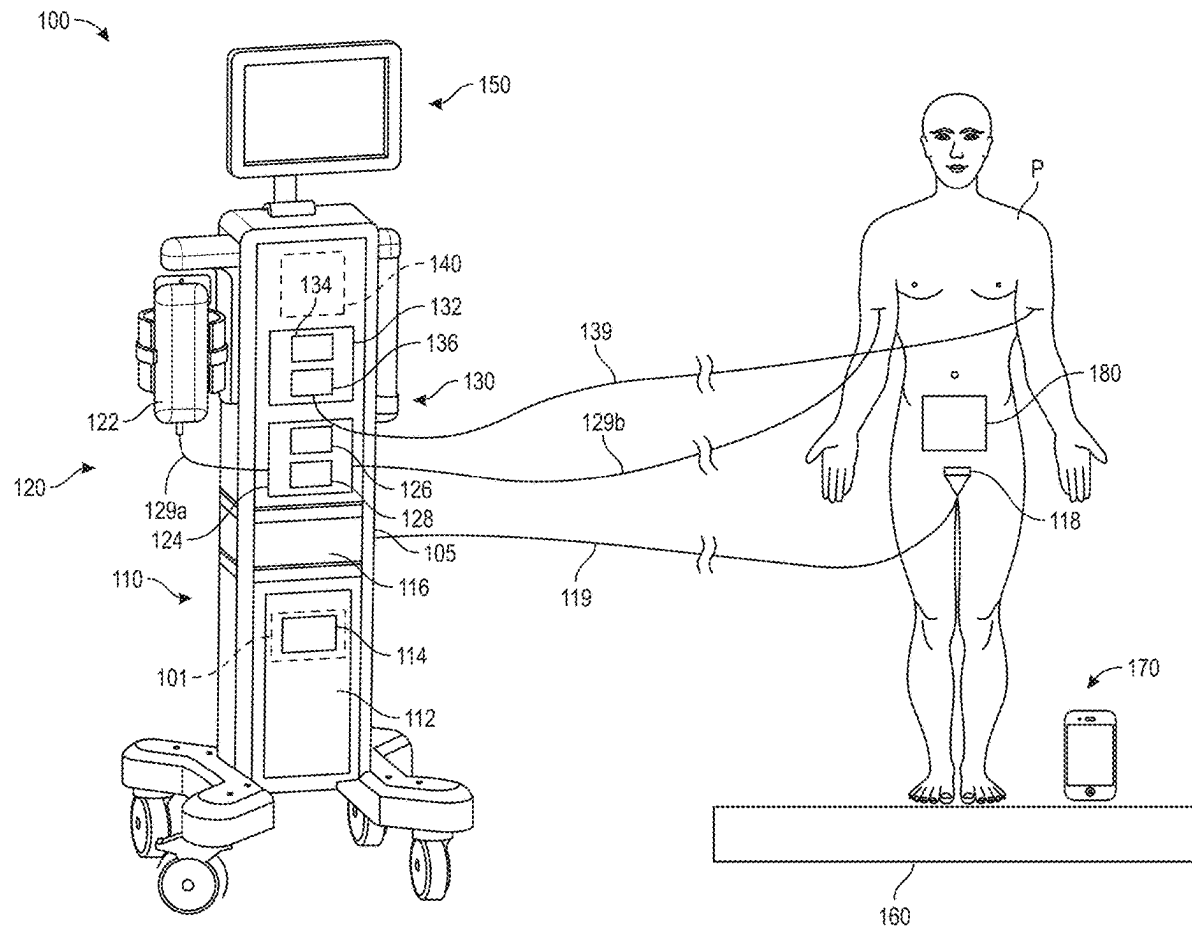
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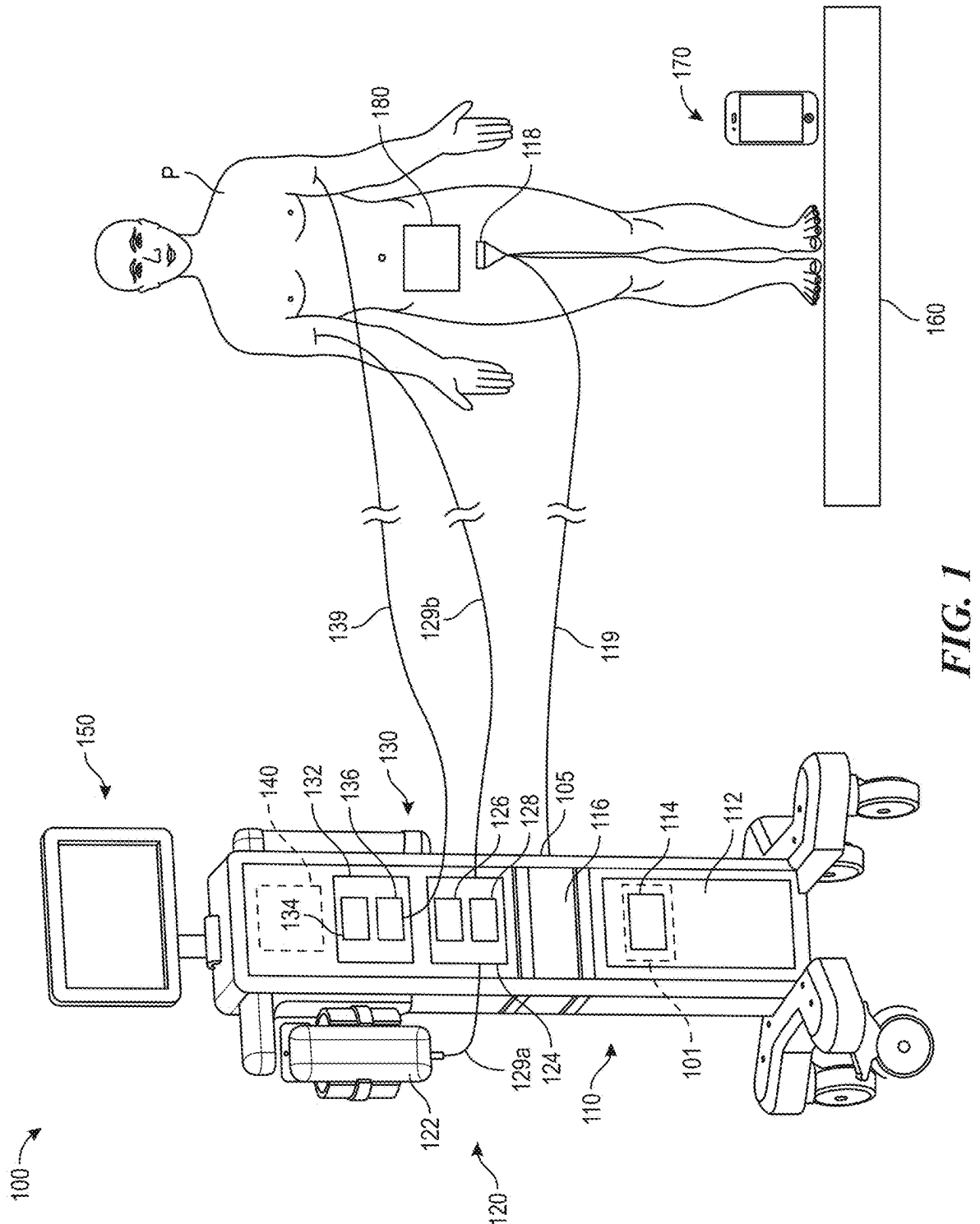
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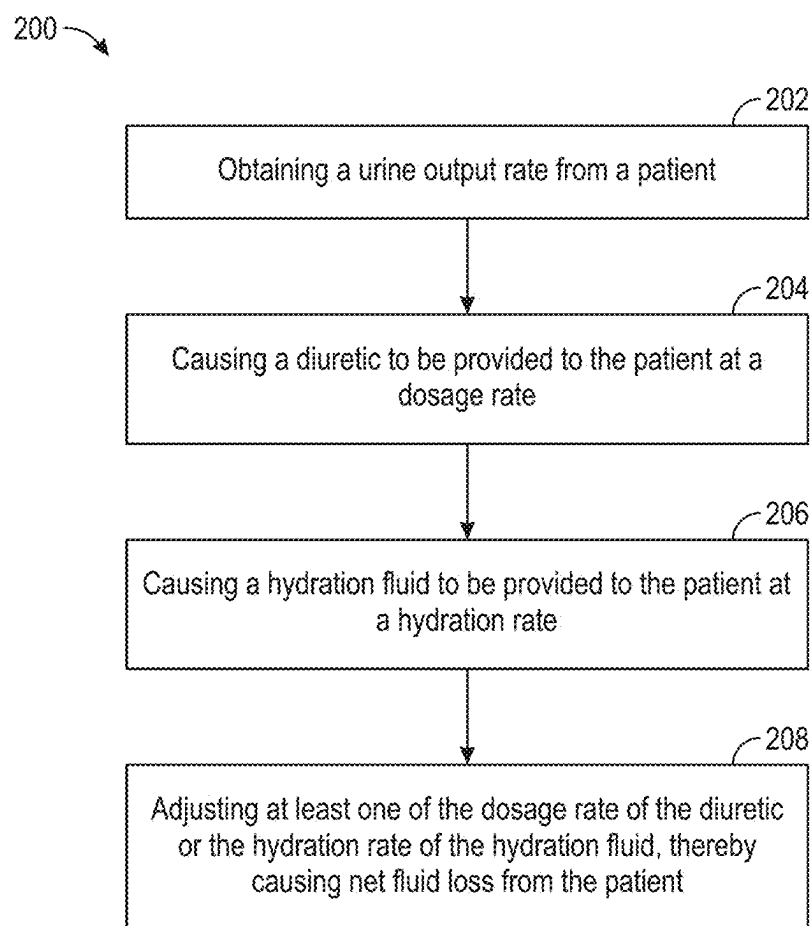
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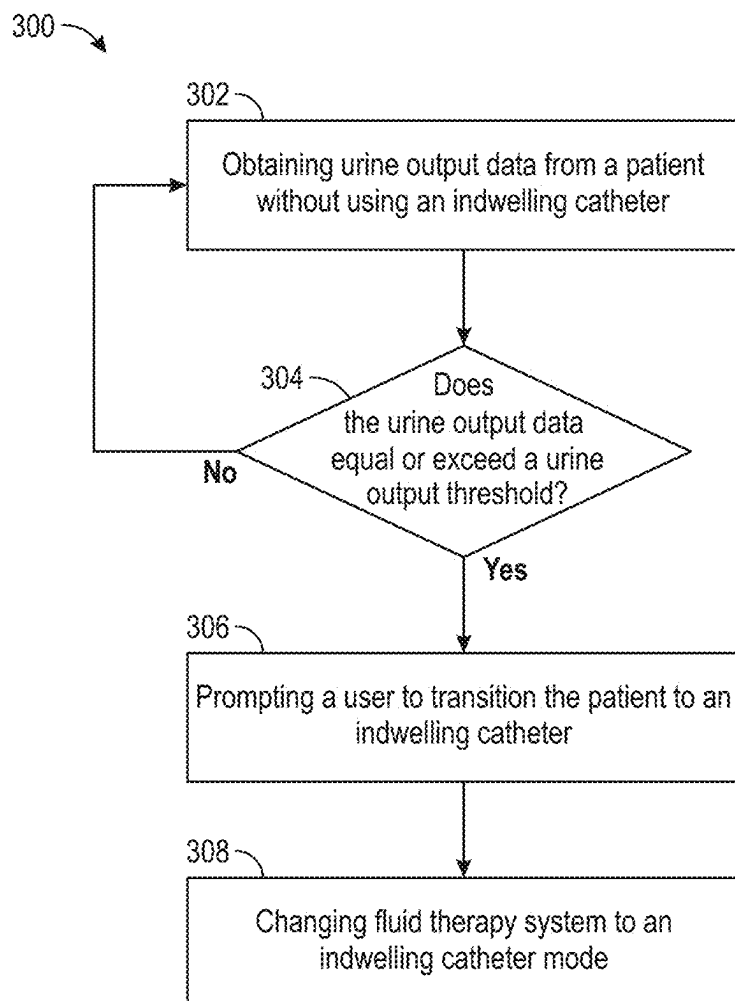
(57) **ABSTRACT**

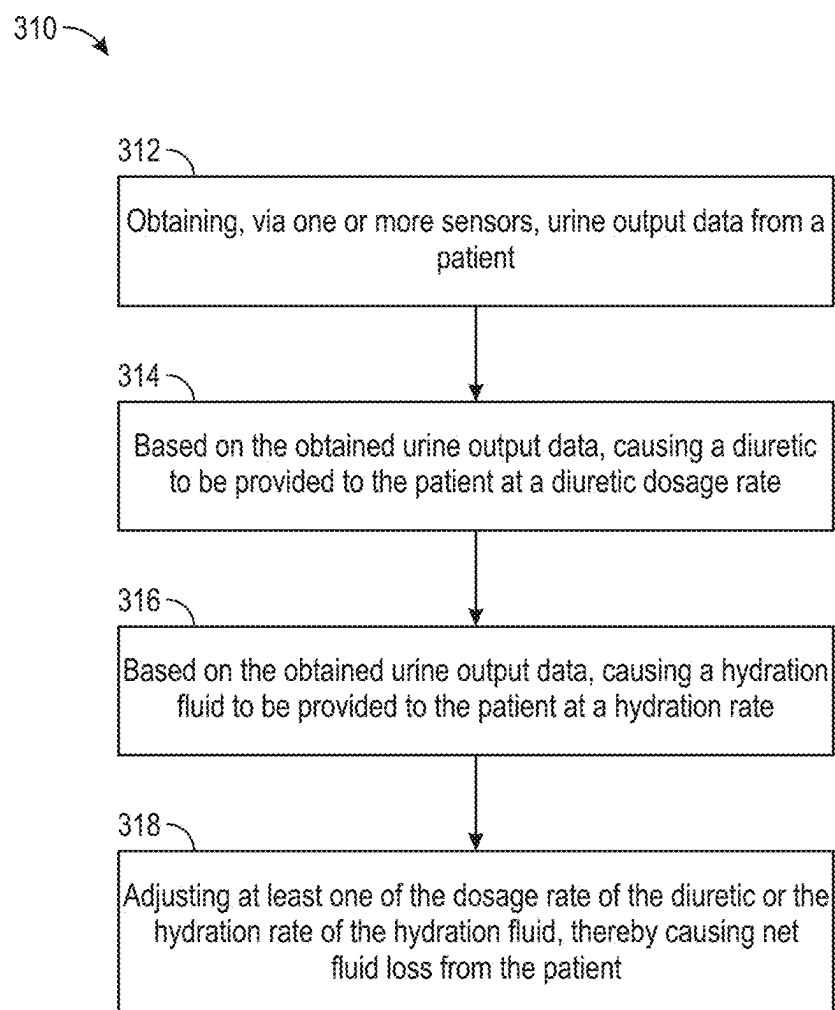
The present disclosure generally relates to fluid therapy based on patient data, and associated systems, devices, and methods. Embodiments of the present technology can obtain multiple inputs of urine output volume data from a patient without using an indwelling catheter, determine an accumulated volume of urine output data based on the obtained multiple inputs, and adjust the patient's fluid therapy based on the accumulated volume and/or the obtained multiple inputs. Additionally, or alternatively, embodiments of the present technology can include one or more sensors that measure a volume and/or a change in volume of urine within the patient's bladder to determine a urine output rate of the patient, without using an indwelling catheter. Accordingly, embodiments of the present technology can advantageously manage a fluid therapy for patients that refuse an indwelling catheter.

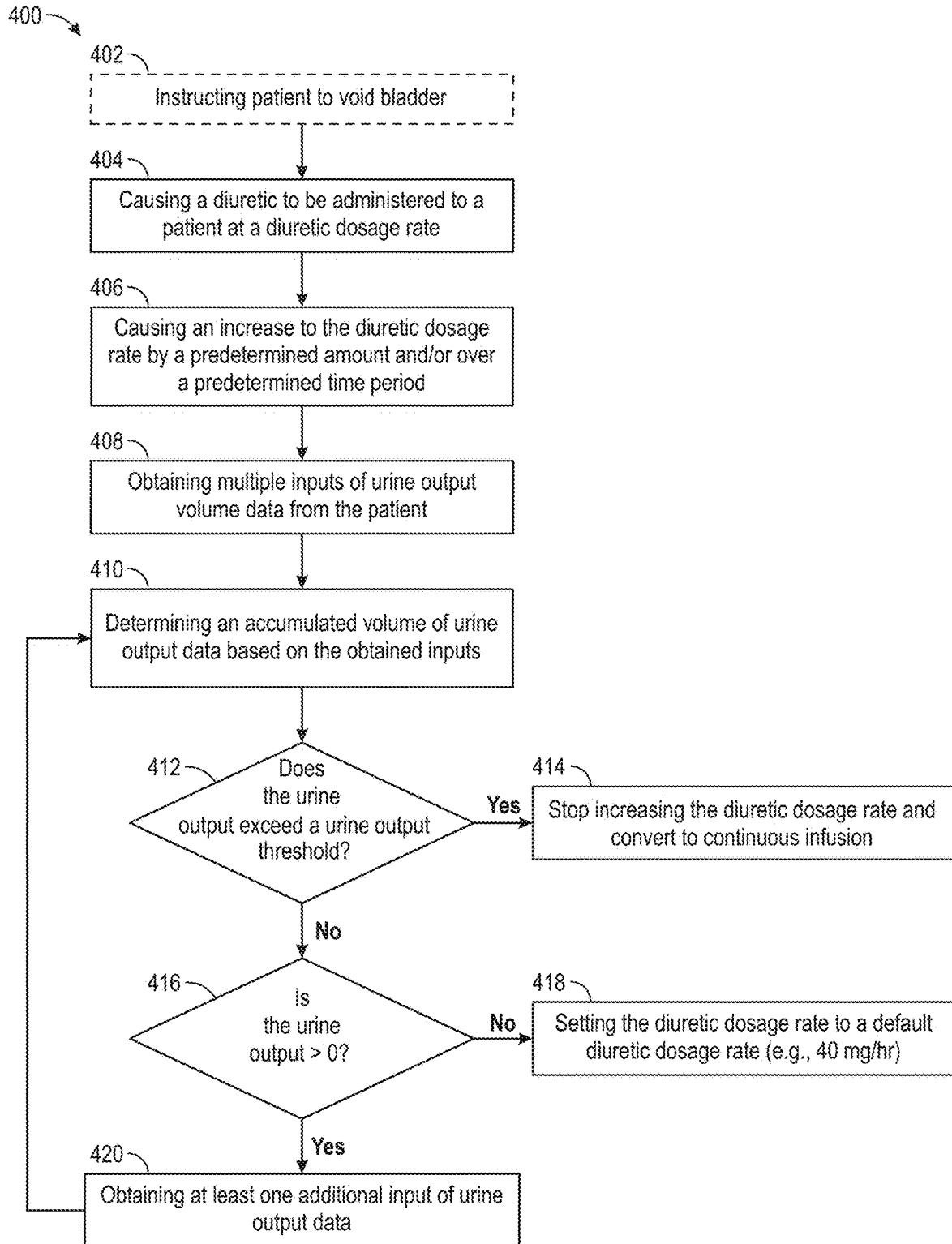




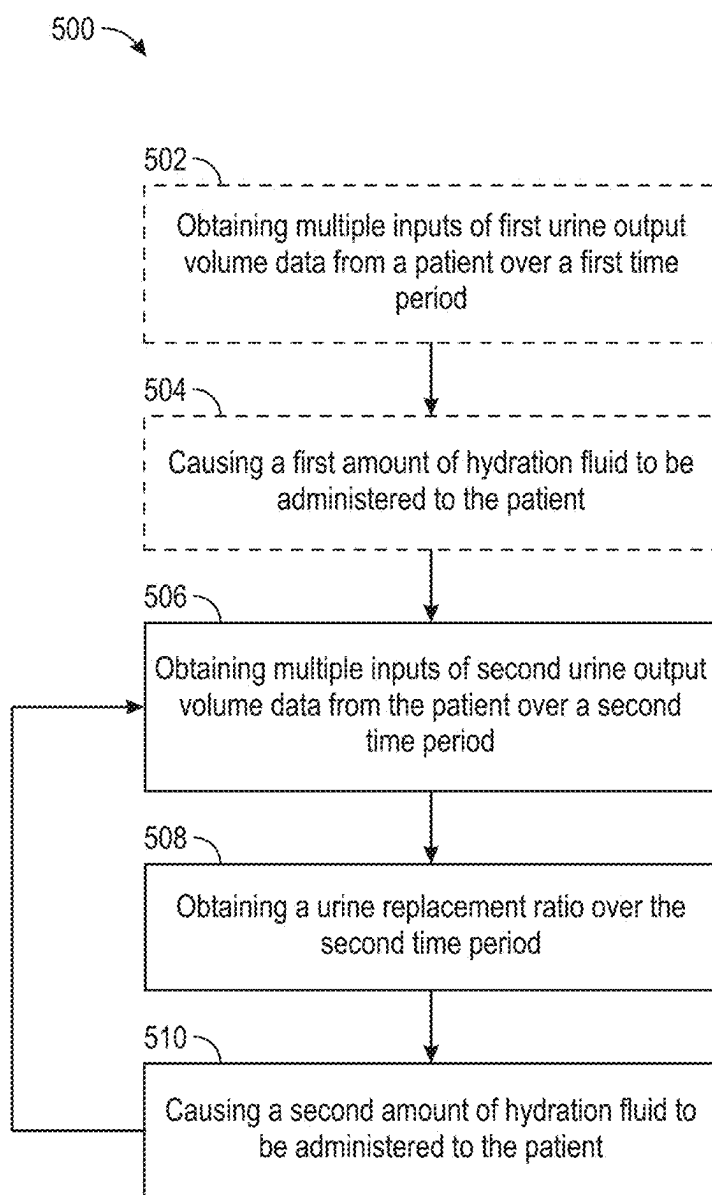
**FIG. 2**

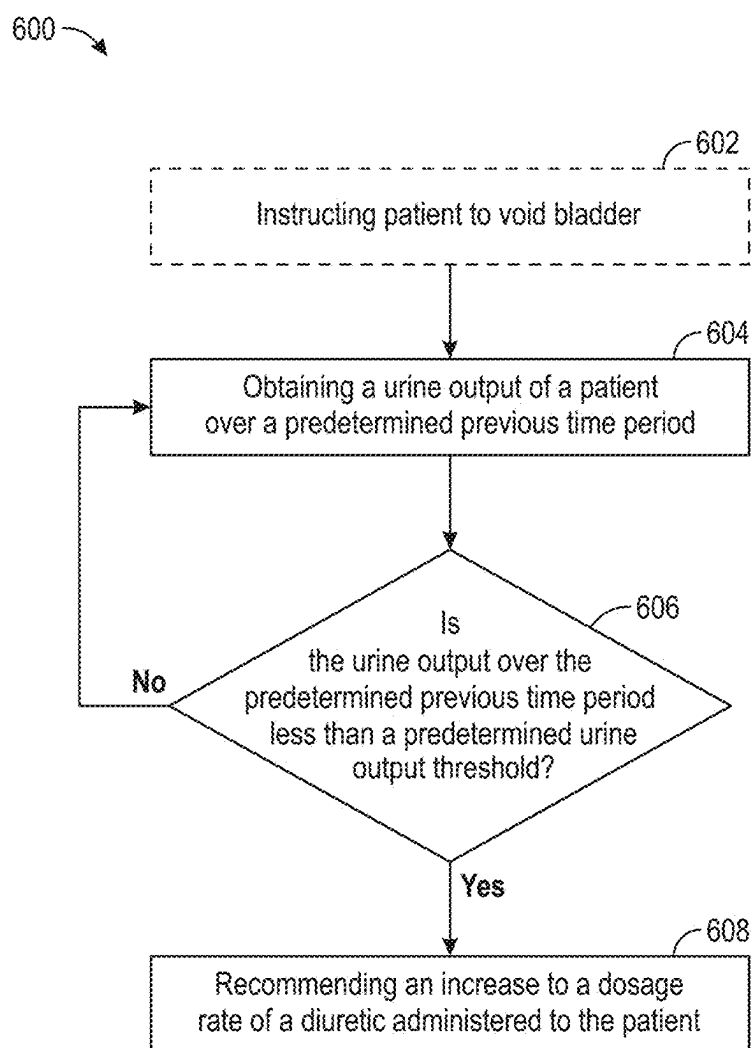
**FIG. 3A**

**FIG. 3B**

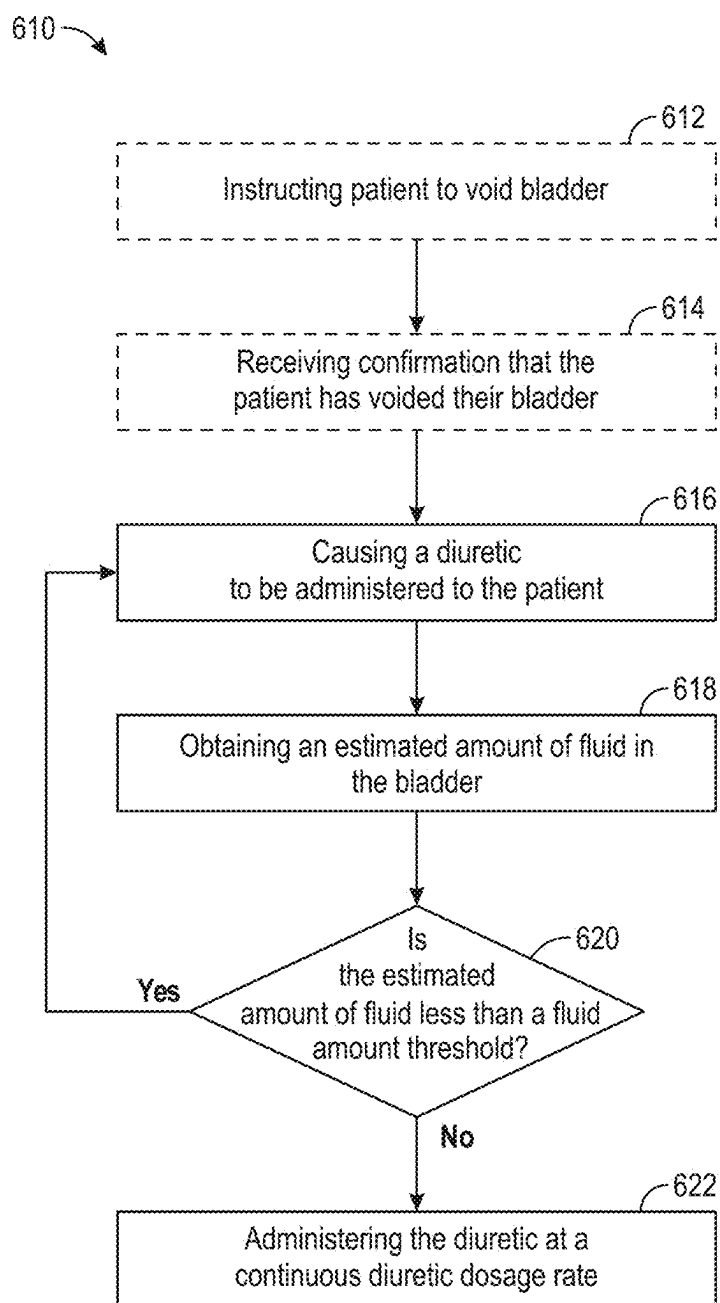


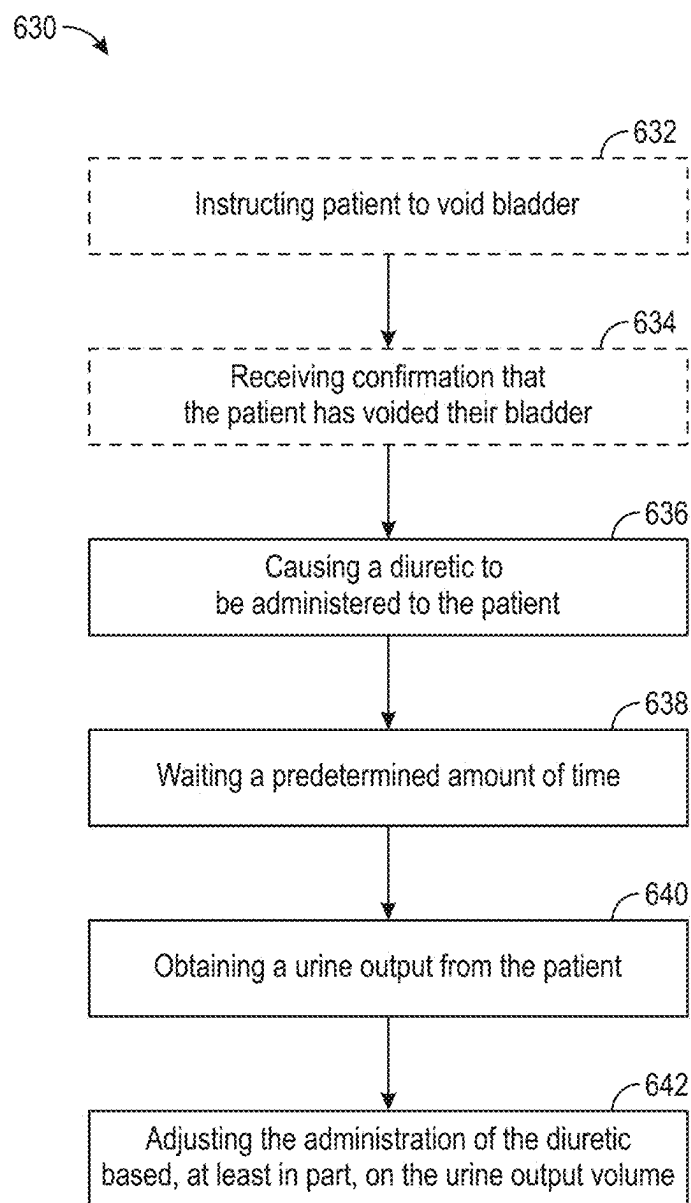
**FIG. 4**

**FIG. 5**

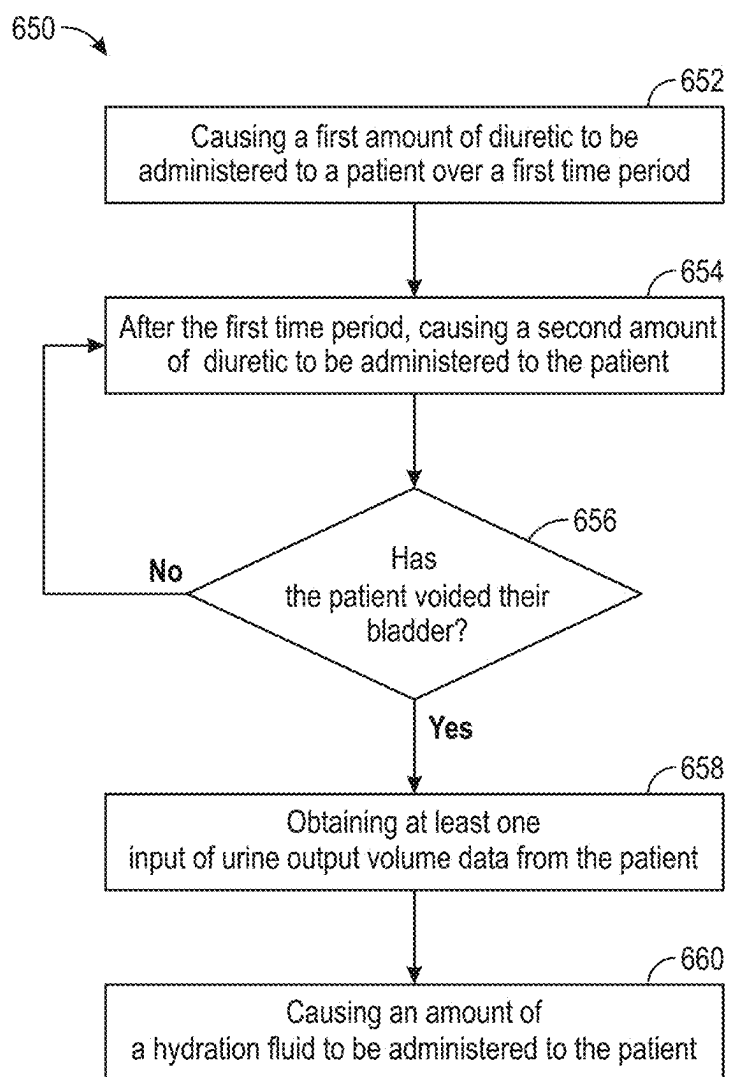
**FIG. 6A**



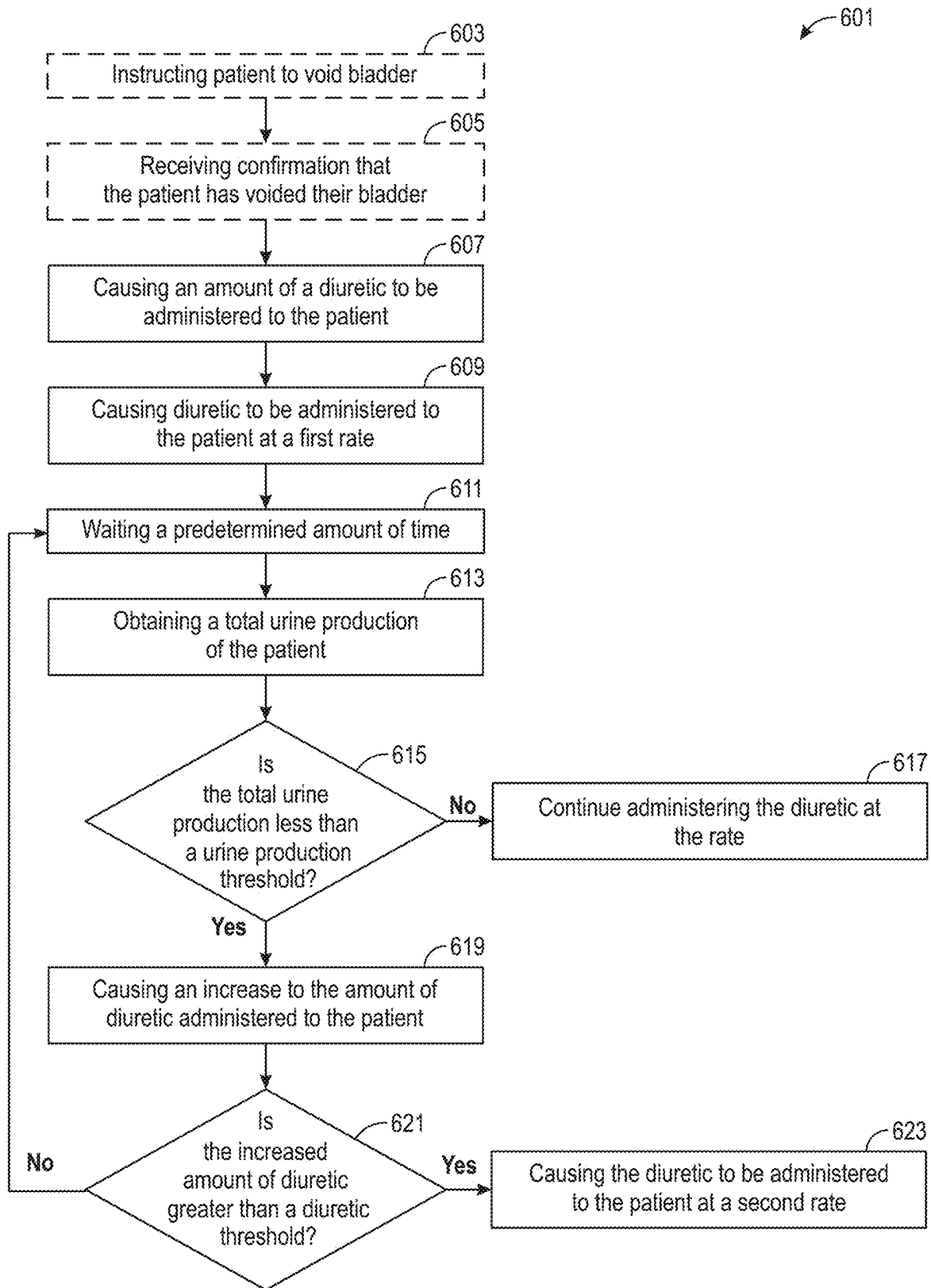
**FIG. 6B**



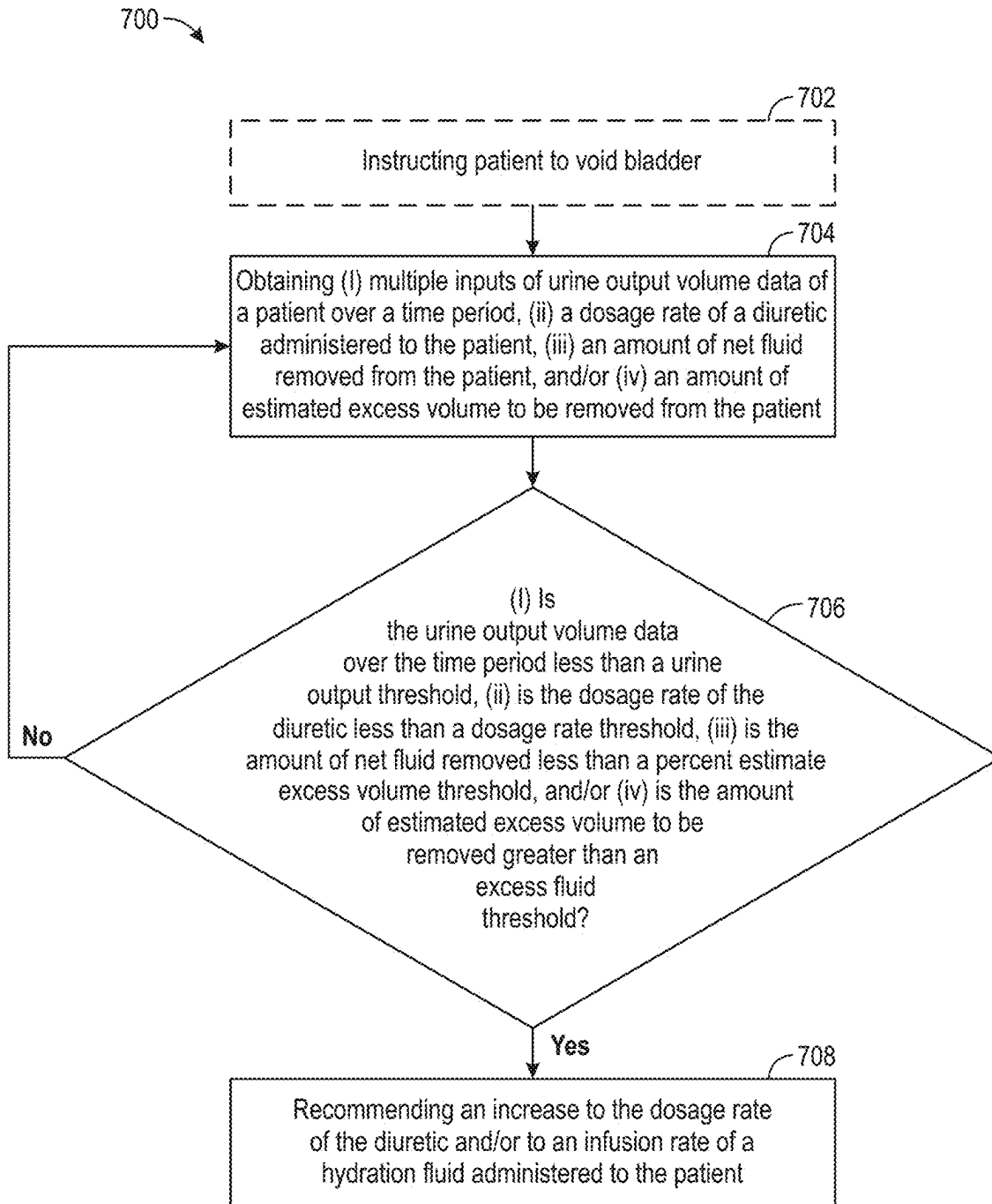
**FIG. 6C**



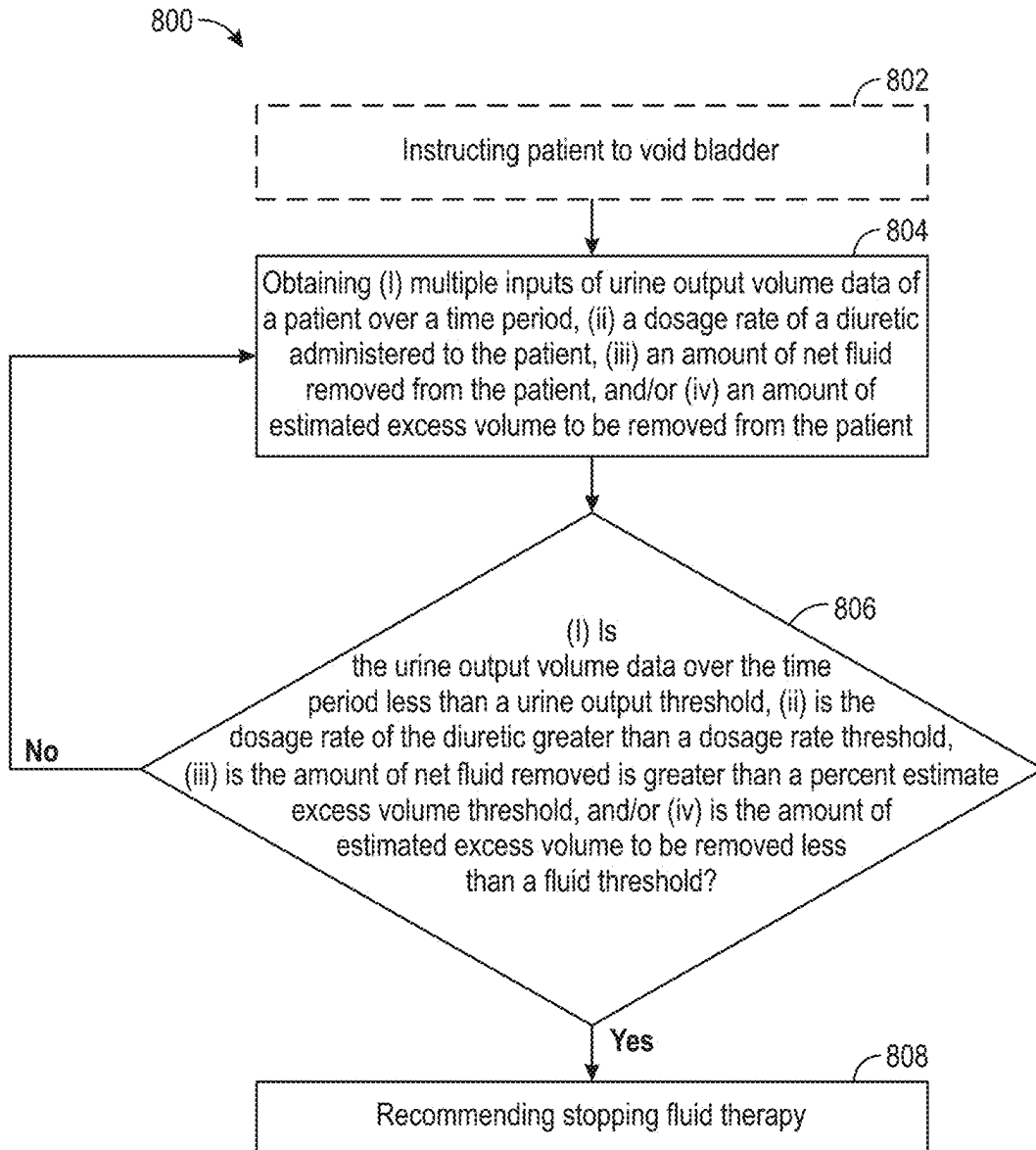
**FIG. 6D**



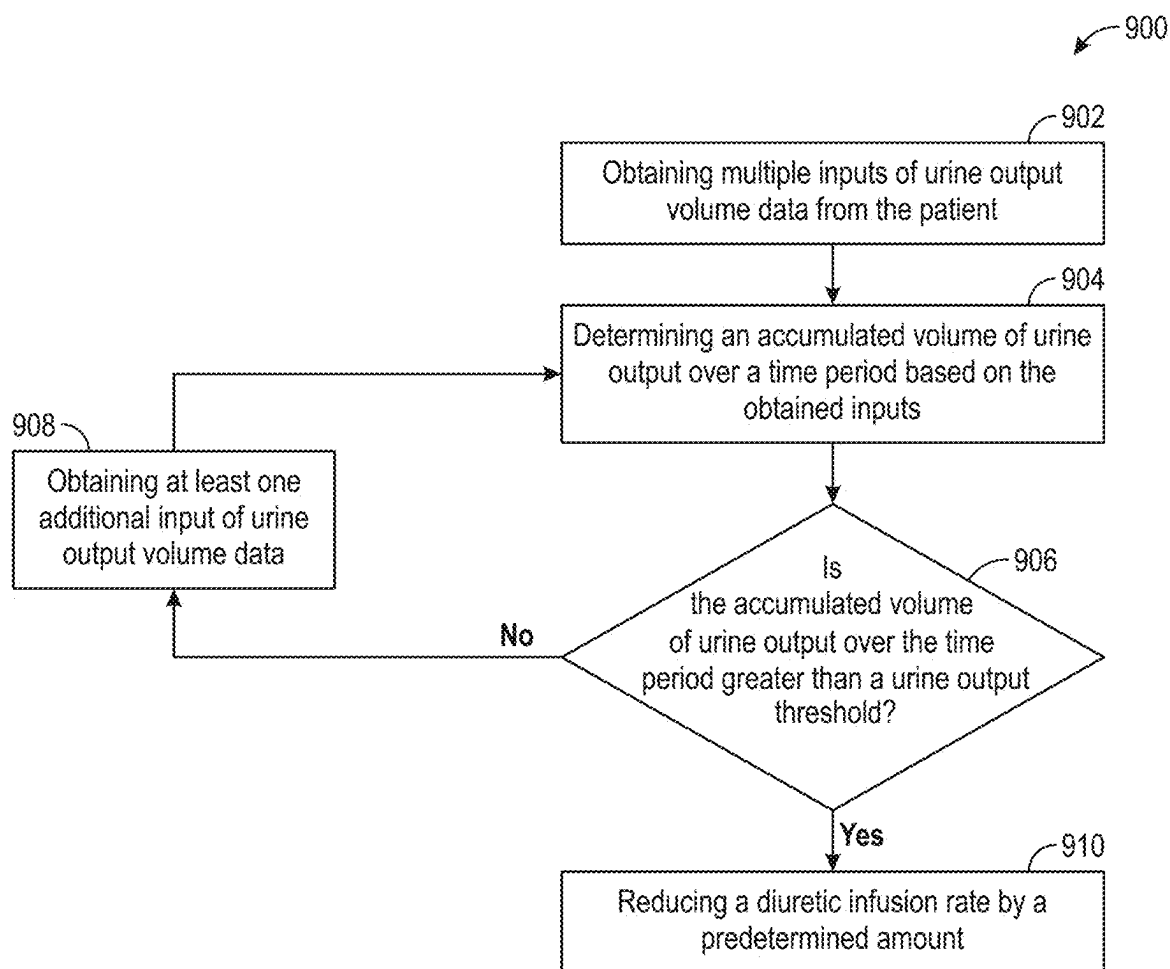
**FIG. 6E**



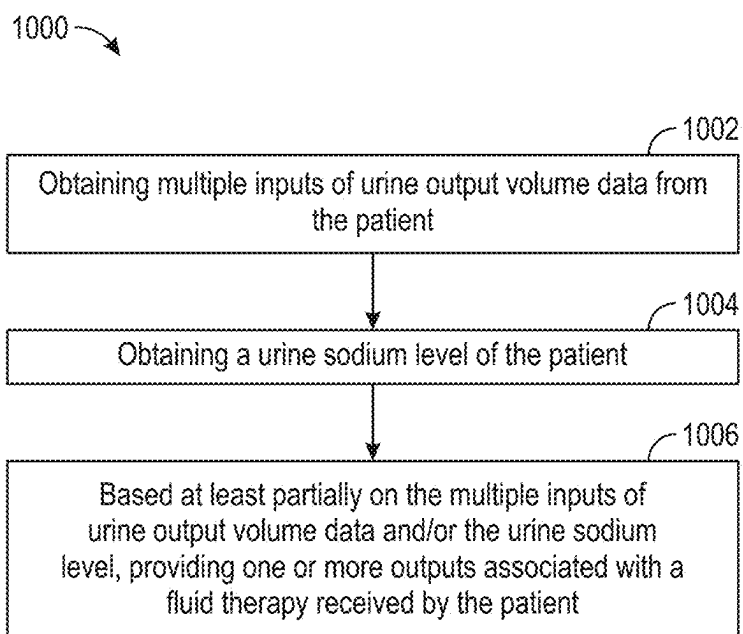
**FIG. 7**



**FIG. 8**



**FIG. 9**



**FIG. 10**



**URINE OUTPUT SENSING WITHOUT USE  
OF AN INDWELLING CATHETER, AND  
ASSOCIATED SYSTEMS, DEVICES, AND  
METHODS**

**CROSS-REFERENCE TO RELATED  
APPLICATION**

[0001] The present application claims priority to U.S. Provisional App. No. 63/554,744; filed Feb. 16, 2024; and titled “URINE OUTPUT SENSING WITHOUT USE OF AN INDWELLING CATHETER, AND ASSOCIATED SYSTEMS, DEVICES, AND METHODS”; and is related to U.S. Pat. No. 11,357,446; filed Dec. 4, 2020; and titled “MANAGING FLUID LEVELS IN A PATIENT AND ASSOCIATED DEVICES, SYSTEMS, AND METHODS;” both of which are incorporated herein by reference in their entireties.

**TECHNICAL FIELD**

[0002] The present disclosure generally relates to medical devices and, in particular, to urine output sensing without the use of an indwelling catheter, and associated systems, devices, and methods.

**BACKGROUND**

[0003] Human physiological systems seek to naturally maintain a balance between fluid intake and fluid excretion. An imbalance in fluid intake and excretion rates may cause the body to retain excess amounts of fluid, also known as fluid overload. Fluid overload can be caused by acute decompensated heart failure (ADHF), chronic heart failure (CHF), or other conditions in which insufficient fluid is excreted. Patients exhibiting fluid overload may suffer from shortness of breath (dyspnea), edema, hypertension, and other undesirable medical conditions.

[0004] To treat fluid overload, patients are typically administered a diuretic drug which induces and/or increases urine production, thus reducing the amount of fluid and sodium in the body. The rate of urine output may be carefully monitored and/or controlled for safety reasons, e.g., to avoid placing undue stress on the patient’s kidneys. Different patients may respond differently to treatment, such that the same diuretic type and/or dosage may produce drastically different urine output rates. However, conventional systems and methods for treating fluid overload may not be capable of accurately monitoring a patient’s urine output and/or responding to changes in urine output. Additionally, conventional treatment systems and devices may not be capable of accommodating high urine production rates, and thus may require a nurse or other healthcare professional to empty and/or replace urine collection bags multiple times during the treatment procedure. Conventional systems and devices may also be prone to air lock and/or interruptions to urine flow.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0005] Features, aspects, and advantages of the presently disclosed technology may be better understood with regard to the following drawings.

[0006] FIG. 1 is a partially schematic view of a fluid management system configured in accordance with embodiments of the present technology.

[0007] FIG. 2 is a flow diagram of a method for treating a patient, in accordance with embodiments of the present technology.

[0008] FIGS. 3A and 3B are block diagrams illustrating methods for treating a patient, in accordance with embodiments of the present technology.

[0009] FIG. 4 is a block diagram illustrating a diuretic dose finding method, in accordance with embodiments of the present technology.

[0010] FIG. 5 is a block diagram illustrating a method associated with providing hydration fluid to a patient, in accordance with embodiments of the present technology.

[0011] FIGS. 6A-6E are block diagrams illustrating methods associated with administering diuretic to a patient, in accordance with embodiments of the present technology.

[0012] FIG. 7 is a block diagram illustrating a method associated with escalating a patient’s fluid therapy, in accordance with embodiments of the present technology.

[0013] FIG. 8 is a block diagram illustrating a method associated with stopping a patient’s fluid therapy, in accordance with embodiments of the present technology.

[0014] FIG. 9 is a block diagram illustrating a method associated with down-titrating a patient’s fluid therapy, in accordance with embodiments of the present technology.

[0015] FIG. 10 is a block diagram illustrating a method of providing outputs associated with a patient’s fluid therapy based at least partially on a urine output (e.g., a urine output rate) and a urine sodium level of the patient, in accordance with embodiments of the present technology.

[0016] A person skilled in the relevant art will understand that the features shown in the drawings are for purposes of illustrations, and variations, including different and/or additional features and arrangements thereof, are possible.

**DETAILED DESCRIPTION**

**I. Overview**

[0017] The present technology is directed to systems for managing (e.g., increasing or decreasing) a patient’s urine output based at least in part on an estimated excess fluid volume of the patient. Embodiments of the present technology relate to infusing diuretic and/or hydration fluid to increase or optimize urine output, net fluid removal, and/or net sodium removal from the patient. Before a patient begins receiving fluid therapy, it is difficult, if not impossible, to predict how the patient will respond to the fluid therapy and/or whether the fluid therapy will be effective to increase or optimize the patient’s urine output, net fluid removal, and/or net sodium removal. While a standard treatment protocol may be effective for some patients, many, if not most, patients can have unique conditions and/or have abnormal responses to the standard treatment protocols that prevent or inhibit optimal therapy. As an example, certain patients may not react to some diuretics and/or may have underlying conditions (e.g., low or high blood pressure) which limit their urine output rates, net fluid removal, and/or net sodium removal, or make treatment to achieve maximum urine output rates, net fluid removal, and/or net sodium removal more difficult. For such patients, additional steps or protocols may be necessary to increase urine output, net fluid removal, and/or net sodium removal and relieve fluid overload conditions. These additional steps or protocols can be based on data associated with a patient receiving therapy, such as the patient’s response to the received therapy (e.g.,

the administered diuretic and/or hydration fluid), and/or on historical treatment data including the treatment responses of one or more other patients. Accordingly, embodiments of the present technology are expected to optimize/customize all or a subset of a diuretic therapy to an individual patient's physiology, for example, to maximize decongestion and/or minimize clinical sequelae.

**[0018]** As described elsewhere herein, embodiments of the present technology can obtain one or more (e.g., multiple) inputs of urine output volume data from a patient without using an indwelling catheter (e.g., a Foley catheter). A typical indwelling catheter, such as a Foley catheter, is configured to be positioned at least partially within a patient's bladder. Accordingly, as the patient's kidneys excrete urine into the bladder, the indwelling catheter allows the excreted urine to flow from the bladder to a location outside the body (e.g., a urine collection container). This urine output is expected to occur automatically (e.g., without the patient voluntarily urinating) and/or continuously (e.g., urine excreted from the kidneys into the bladder is removed from the patient via the indwelling catheter, being held in the bladder for no more than 1 second, 5 seconds, 10 seconds, 15 seconds, 30 seconds, 1 minute, 5 minutes, 10 minutes, combinations thereof, and/or one or more other suitable amounts of time). Therefore, the indwelling catheter can be used to measure urine excretion by the patient's kidneys and, in turn, determine a urine output rate for the patient. However, many patients, clinicians, and/or institutions do not utilize indwelling catheters, opting instead for external catheters, such as condom catheters or PureWick™ catheters, or other non-indwelling catheters. External catheters are placed external to the patient and collect patient urination. Whereas indwelling catheters do not require patient urination (voluntary or otherwise) to receive and collect urine, external catheters rely on patient urination (voluntary or otherwise) to receive and collect urine. Often, patients that use external catheters urinate in large volumes or boluses (e.g., up to 1 liter) that are intermittent/periodic (e.g., no less than 10 minutes, 20 minutes, 30 minutes, combinations thereof, and/or one or more other suitable lengths of time apart from one another) throughout therapy. These patients also rarely/infrequently urinate while sleeping. Accordingly, whereas indwelling catheters can measure urine excretion from the kidneys, external catheters instead measure urination from the bladder. This can make it difficult to accurately determine a continuous urine and/or sodium output rate (i.e. urine and/or sodium excretion rate from the kidneys) for patients that use non-indwelling catheters and, accordingly, difficult to adjust fluid therapy received by patients that use non-indwelling catheters based on those patients' urine and/or sodium output rates. However, embodiments of the present technology can obtain one or more (e.g., multiple) inputs of urine output volume data from a patient without using an indwelling catheter and use that data to adjust one or more aspects of the patient's fluid therapy. For example, in some embodiments a fluid therapy system can obtain multiple inputs of urine output volume data from a patient without using an indwelling catheter, determine an accumulated volume of urine output data based on the obtained multiple inputs, and adjust the patient's fluid therapy based at least partially on the accumulated volume and/or the obtained multiple inputs. Additionally, or alternatively, the fluid therapy system can include one or more sensors disposed externally on and/or around the patient that measure a

volume and/or a change in volume of urine within the patient's bladder, e.g., to determine a urine output rate of the patient. In doing so, embodiments of the present technology can advantageously manage a fluid therapy for patients that refuse an indwelling catheter.

**[0019]** Embodiments of the present technology can manage a patient's fluid removal (including to, e.g., increase or optimize the patient's urine output, net fluid removal, and/or net sodium removal) based at least in part on the measured urine output and the physician's estimated excess fluid volume. For example, in some embodiments if a patient's urine output drops below a pre-defined rate and the patient has lost 80% or more of the estimated excess fluid volume or less than 1 L of estimated excess fluid remains to be removed from the patient, then the system may determine that therapy should be stopped (e.g., automatically stopped) immediately or after a period of time (e.g., one hour). Alternatively, if a patient's urine output drops below a pre-defined rate and less than 80% of the estimated excess fluid volume has been removed and/or more than 1 L of estimated excess fluid remains to be removed from the patient, then the system may determine that it is necessary to take steps to increase urine production. In such embodiments, the system may recommend (e.g., via software, labeling, and/or combinations thereof) infusing or otherwise administering a second diuretic in addition to a first diuretic already being infused, and/or adjusting a rate of hydration fluid infusion. In doing so, embodiments of the present technology can advantageously manage a patient's urine output by ceasing one or more aspects of fluid therapy (e.g., diuretic infusion) for instances of sufficient fluid loss and improving fluid therapy by increasing urine output for instances of insufficient fluid loss.

**[0020]** Various aspects of one or more embodiments of the present technology can be based at least partially on one or more models ("model(s)"), such as artificial intelligence (AI) and/or machine learning (ML) models. Individual ones of these models can be trained using historical treatment data from one or more other patients and configured to determine and/or predict information about the patient receiving treatment, and/or otherwise inform the system's and/or the user's decisions regarding the patient's therapy. In at least some embodiments, the model(s) can be configured/trained to compare patient data with training data and/or data associated with fluid therapy and/or other treatments administered to one or more other patients. For example, for a given patient, the model(s) can be configured/trained to identify data associated with one or more other patients that have an at least generally similar treatment profile. A treatment profile can be at least generally similar to data for a given patient if/when data associated with the treatment profile and the data for the given patient share one or more treatment characteristics (e.g., patient diuretic resistance, glomerular filtration rate (GFR), patient age, patient gender, overall patient health, underlying health conditions, renal function, demographics, clinician estimated excess fluid, combinations thereof, and/or one or more other suitable treatment characteristics), urine rate profile (e.g., urine rate, slope of urine rate curve, plot of urine rate over time) an amount of fluid already removed from patient, a prior response to fluid therapy, combinations thereof, and/or other suitable treatment profile data. In some embodiments, rules for identifying an at least generally similar or identical treatment profile can be programmed into the model(s),

and/or may correspond to values being within a range or threshold of one another (e.g., less than a 5%, 10%, 15%, 20%, 25%, or 30% difference). In other embodiments, the model(s) can identify/create rules, parameters, thresholds, combinations thereof, and/or one or more other suitable processes for identifying at least generally similar or identical treatment profiles, e.g., during training. Generally, the model(s) are expected to improve the effectiveness of the fluid therapy steps/blocks/protocols described herein. In some embodiments, the model(s) are expected to improve a specific patient's response to the fluid therapy steps/blocks/protocols described herein. In further embodiments, the model(s) can predict whether a patient is expected to respond to fluid therapy and/or are expected to optimize (e.g., maximize) a patient's response to the fluid therapy steps/blocks/protocols described herein in real-time, for example, based on data received from the patient associated with the patient's response to the fluid therapy.

**[0021]** The headings provided herein are for convenience only and are not intended to limit or interpret the scope or meaning of the technology.

## II. Fluid Management Systems and Methods

**[0022]** The present technology is generally directed to systems, devices, and associated methods for fluid therapy based on patient data, including managing fluid levels of the patient based at least partially in response to data received from the patient before and/or during the fluid therapy. In some embodiments, the systems, devices, and methods described herein are used to treat a patient for fluid overload. To treat fluid overload, patients can be administered a diuretic drug which induces and/or increases urine production. For example, loop diuretics are diuretics that act at the ascending limb of the loop of Henle in the kidney, and include bumetanide (Bumex®), ethacrynic acid (Edecrin®), furosemide (Lasix®), torsemide (Demadex®), thiazide and thiazide-like diuretics (e.g., chlorothiazide, metolazone), potassium-sparing diuretics (e.g., amiloride, spironolactone), carbonic anhydrase inhibitors (e.g., acetazolamide), Vaptans (e.g., Conivaptan), SGLT2 inhibitors, and osmotic diuretics (e.g., mannitol). Diuretics can be given orally as a pill or as an intravenous (IV) injection. IV diuretics can be used when oral diuretics are no longer effective and/or able to be absorbed.

**[0023]** The short-term effects of diuretics on a patient's urine production may be difficult to predict, particularly at early stages of treatment. For example, one patient may produce much less urine than expected for a given dose of diuretic, while another patient administered the same dose may produce very large amounts of urine. Low urine production can prolong treatment time and/or reduce treatment efficacy, while high urine production can raise concerns of hypotension, hypovolemia, electrolyte imbalance (e.g., hypokalemia), and/or vital organ damage. High doses of a diuretic, regardless of the urine response, can also raise concerns about ototoxicity. Due to these uncertainties, physicians typically initially prescribe a conservative (e.g., low) diuretic dosage and often wait a full day or longer before considering whether to increase the diuretic dosage. If the physician determines that a higher diuretic dosage is needed, the physician may slowly and incrementally increase the dosage until the patient's urine output reaches the desired level and/or rate. However, this approach can prolong the time the patient remains in the fluid overloaded condition,

which can exacerbate the patient's underlying clinical state. For example, conservative treatment procedures can require hours or even days before the patient's urine output is sufficiently high to cause significant fluid loss and relieve the fluid overload condition. The patient may be hospitalized for several days (e.g., 4-5 days), which can be expensive and burdensome. Additionally, the long-term treatment efficacy may be limited, such that approximately 25% of patients are readmitted for fluid overload within 30 days.

**[0024]** To overcome these and other challenges, the present technology provides systems, and associated devices and methods, for managing a patient's fluid levels. In some embodiments, the present technology can (i) improve efficacy, safety, and quality of fluid management treatment, (ii) improve resource management in hospitals and other clinical settings, (iii) quickly assess if a patient is diuretic resistant (e.g. within the first few hours of treatment), and/or (iv) increase diuretic efficiency (e.g., the amount of urine and/or excreted electrolytes (e.g., sodium) obtained over a given time per mg of diuretic infused intravenously). The embodiments described herein can increase net removal of fluid and/or electrolytes (e.g., sodium and/or chloride), and can also treat fluid overload conditions in a more efficient manner (e.g., shorter timeframe and/or higher net fluid loss).

**[0025]** FIG. 1 is a partially schematic illustration of a fluid management system 100 ("system 100") for monitoring urine output and/or control fluid infusion into a patient P, in accordance with embodiments of the present technology. The system 100 includes a urine collection and monitoring system 110 ("urine system 110"), an automated hydration fluid infusion system 120 ("hydration system 120"), an automated diuretic infusion system 130 ("diuretic system 130"), a controller or control system 140 ("controller 140"), and a display or input/output unit 150 ("display 150"). The controller 140 can be operably coupled to each of the urine system 110, hydration system 120, diuretic system 130, and/or display 150. The system 100 can further include a console or structure 105 ("console 105") that incorporates, houses, and/or otherwise supports all or portions of the urine system 110, hydration system 120, diuretic system 130, the controller 140, and/or the display 150.

**[0026]** The urine system 110 is configured to collect urine from the patient P and/or monitor the patient's urine output (e.g., urine output amount and/or rates). The urine system 110 can include one or more collection containers 112 ("container 112") configured to hold urine, such as a disposable bag or other collection device. The container 112 can be fluidly coupled to the patient P via a fluid line 119 (e.g., a tubing line). The fluid line 119 can be connectable to a disposable catheter 118 (e.g., a non-indwelling catheter, including external catheters such as Texas Condom catheters, PureWick catheters, and/or other suitable external catheters) configured to receive fluid from the bladder of the patient P.

**[0027]** In some embodiments, urine flow through the fluid line 119 is driven by the patient's urine production, gravity (e.g., the bladder of the patient P is positioned higher than the container 112), and/or a siphon effect between the patient's bladder and the container 112. In other embodiments, the urine system 110 can also include a pump, vacuum, or other device (not shown) operably coupled to the fluid line 119 for actuating urine flow through the fluid line 119 and into the container 112. The pump can be or include any device suitable for pumping fluid, such as a peristaltic

pump. The pump can be used to initiate urine flow from the patient's body at the start of the procedure. The pump can also be used to clear air locks and/or other obstructions from the fluid line 119.

**[0028]** The urine system 110 can include one or more sensors 114 (“sensor(s) 114”) configured to detect one or more characteristics of the patient's urine output (e.g., an amount and/or rate of urine output) and/or one or more electrical, chemical, and/or physical properties of the patient's urine including, e.g., urine sodium concentration, urine conductivity, urine temperature, urine oxygen content, and/or combinations thereof). Accordingly, the sensor(s) 114 can generate data based at least partially on the patient's urine such that the controller 140 can monitor and/or compute the patient's urine output based on the data generated by the sensor(s) 114.

**[0029]** The urine output can be determined in many different ways, such as based on urine flow (e.g., through the fluid line 119 and/or into the container 112), the amount of urine in the container 112 (e.g., based on the weight of the container 112, level of urine in the container 112, and/or combinations thereof), and/or other properties associated with the urine. The sensor(s) 114 can include one or more of the following: a flow sensor, drip counter, fluid weight sensor, fluid level sensor, float sensor, optical sensor, ultrasonic sensor, and/or other sensors known in the art suitable for measuring a urine output amount and/or rate. In the embodiment of FIG. 1, the sensor(s) 114 are positioned at the console 105. In other embodiments, however, some or all of the sensor(s) 114 can be at a different location in the system 100, such as on or in the line 119, on or in the container 112, and/or on or in the patient P.

**[0030]** In some embodiments, the sensor(s) 114 can include at least one sensor configured to measure one or more characteristics of the urine, in addition to detecting the patient's urine output. For example, the sensor(s) 114 can be configured to measure urine temperature, urine conductivity, urine oxygenation, urine specific gravity, and/or levels of one or more analytes in the urine (e.g., creatinine, sodium, potassium, combinations thereof, and/or one or more other suitable analytes). Such characteristics can be useful in, e.g., determining effectiveness of a particular therapy, whether the patient P is in or could be approaching a critical condition, and/or to inform diuretic and/or hydration fluid administration. For example, urine conductivity and/or urine electrolytes (e.g., sodium) can indicate whether the patient is responding well to the fluid therapy, or whether the patient is in a critical condition and fluid therapy should cease. In some embodiments, urine conductivity (either alone or in combination with urine specific gravity) is used as a proxy for measurements of urine sodium and/or other urine electrolytes, e.g., a higher urine conductivity can correlate to higher urine sodium levels and a lower urine conductivity can correlate to lower urine sodium levels. The urine conductivity and/or urine electrolyte levels can be used to determine a patient's actual urine sodium content and, accordingly, determine the patient's adjusted urine output rate. In some embodiments, the patient's actual urine sodium content can be measured directly by, e.g., one or more of the sensors 114. As another example, urine temperature measurements can be used to detect urine flow (e.g., based on heat loss through the fluid line 119). The urine temperature

can also be used as a proxy for the patient's body temperature, which in turn can correlate to the patient's current clinical state.

**[0031]** Optionally, the sensor(s) 114 can include at least one sensor configured to monitor the status of the urine collection procedure, such as whether urine collection is proceeding normally, whether there are interruptions in urine flow, whether there is a blockage or leak in the urine system 110, and/or combinations thereof.) For example, the sensor(s) 114 can include a leak sensor configured to detect whether a leakage is present in the urine system 110 (e.g., at or near the fluid line 119, catheter 118, and/or container 112). Leaks can be detected based on changes in urine flow rate, changes in pressure, the presence of moisture, or any other suitable parameter. In some embodiments, the controller 140 is configured to analyze the data from the leak sensor and/or other sensor(s) 114 to differentiate between low urine output rates versus leaks in the urine system 110. In these and/or other embodiments, one or more leak sensors can be positioned on and/or around the patient P, e.g., to detect leaks from the catheter 118.

**[0032]** As another example, the sensor(s) 114 can include a pressure sensor configured to measure the fluid pressure in the fluid line 119. The controller 140 can use the pressure measurements to monitor the status of urine flow, and optionally, detect whether there are any interruptions (e.g., decreases, sudden stoppages) or other issues with urine collection. In some embodiments, the controller 140 analyzes the pressure measurements to determine whether interruptions are due to low urine flow (e.g., the patient's bladder is empty or nearly empty), an air lock or other obstruction in the fluid line 119 (e.g., based, at least in part, on the pressure rising above a predetermined pressure threshold), a leak in the urine system 110 and/or a kink in the fluid line 119 and/or catheter 118. The controller 140 can alert the user if manual intervention is helpful or needed (e.g., to clear the obstruction, fix the leak, remove kinks from the fluid line 119, and/or combinations thereof). In embodiments where the urine system 110 includes a pump, the controller 140 can automatically activate the pump and/or increase the pumping rate to clear the obstruction from the fluid line 119.

**[0033]** The hydration system 120 can include at least one hydration fluid source 122 (“fluid source 122”—a bag, bottle, reservoir, and/or combinations thereof) containing a hydration fluid, such as saline (e.g., a premixed saline solution), Ringer's lactate solution, and/or other any other liquid solution suitable for infusion in and/or configured to prevent or treat dehydration of the patient P. The hydration fluid can be isotonic, hypertonic, or hypotonic, e.g., depending on the patient's condition and/or other treatment considerations. Optionally, the composition of the hydration fluid (e.g., sodium, chloride, potassium, bicarbonate, other substances and/or compounds, and/or combinations thereof) can be varied based on the patient's condition and/or expected or measured electrolyte loss during the treatment procedure.

**[0034]** The fluid source 122 can be connected to the patient P via at least one fluid line (e.g., an IV line or other tubing), such as first fluid line 129a and a second fluid line 129b. The fluid source 122 can be operably coupled to one or more hydration fluid components 124 for actuating and/or monitoring hydration fluid infusion via the first and second fluid lines 129a-b, such as a hydration fluid pump 126 and/or at least one hydration fluid sensor 128 (“fluid sensor 128”).

In the illustrated embodiment, the fluid source **122** is fluidly coupled to the hydration fluid pump **126** via the first fluid line **129a**, and the hydration fluid pump **126** can pump the hydration fluid into the patient P via the second fluid line **129b**. The hydration fluid pump **126** can be or include a peristaltic pump or other pump suitable for infusing a fluid into the patient's body (e.g., via an IV route or another route).

[0035] The fluid sensor **128** can be configured to determine an amount and/or rate of hydration fluid flowing from the fluid source **122** toward the patient P, and can include a flow sensor, pressure sensor, and/or other sensor configured to determine fluid output from the pump **126**. Alternatively, or in combination, the fluid sensor **128** can monitor hydration infusion rate by measuring the pumping rate of the pump **126** (e.g., the number of rotations of the pump **126** per minute). As described elsewhere herein, the controller **140** can be operatively coupled to the hydration system **120** and can receive sensor data from the fluid sensor **128** to determine a hydration fluid infusion rate. The controller **140** can control the pumping rate of the pump **126** to control the amount and/or rate of hydration fluid provided to the patient P.

[0036] Optionally, the amount of hydration fluid in the fluid source **122** can be monitored, e.g., based on weight, volume, fluid levels, flow rates, and/or combinations thereof. In such embodiments, the fluid source **122** can be operably coupled to an additional sensor separate from the fluid sensor **128** (not shown), such as a fluid level monitor, float sensor, weight sensor, optical sensor, drip counter, flow measurement sensor, or the like. The additional sensor can provide an independent source of measurement data for determining and/or verifying the amount and/or rate of hydration fluid being provided to the patient P, which can be helpful for improving measurement accuracy.

[0037] In some embodiments, the hydration system **120** includes at least one sensor configured to detect the presence of the fluid source **122**, such as a location sensor, optical sensor, weight sensor, one or more other sensors, and/or combinations thereof. The hydration system **120** can use the sensor data to automatically determine whether the fluid source **122** is present or absent, e.g., to assess whether the system **100** is ready to initiate the fluid therapy treatment. Optionally, the sensor data can be used to detect if the user is removing the fluid source **122** during the treatment procedure, e.g., to switch an empty or nearly empty fluid source **122** with a new fluid source **122**. In such embodiments, the system **100** can automatically pause hydration fluid infusion until the fluid source **122** has been replaced. Accordingly, the user can switch fluid sources **122** without having to inform the system **100** or manually pause the procedure.

[0038] The diuretic system **130** can be configured to automatically provide a diuretic to the patient P. The diuretic system **130** can include a diuretic source **134** (e.g., syringe, bag, reservoir, and/or combinations thereof) containing a diuretic, such as bumetanide (Bumex®), ethacrynic acid (Edecrin®), furosemide (Lasix®), torsemide (Demadex®), and/or other diuretics known in the art, each of which may be part of a fluid solution (e.g., a mixture of saline and a diuretic or other agent). In some embodiments, the identity and/or concentration of the diuretic can be received by the controller **140** via user input (e.g., using the display **150**), by

scanning a barcode of the diuretic source **134** or other container of the diuretic, and/or any other suitable technique.

[0039] The diuretic source **134** can be connected to the patient P via a fluid line **139** (e.g., an IV line or other tubing). The diuretic source **134** can also be operably coupled to one or more diuretic components **136** for actuating and/or monitoring diuretic delivery via the fluid line **139**. For example, the diuretic components **136** can include a diuretic pump configured to pump the diuretic through the fluid line **139** and toward the patient P. The diuretic pump can include a peristaltic pump, a syringe pump, a metering pump, or other device suitable for delivering the diuretic to the patient P at a plurality of dosage rates. The diuretic pump can deliver the diuretic according to any suitable delivery profile, such as at a controlled continuous rate and/or in controlled boluses delivered at regular intervals through the fluid line **139**.

[0040] In some embodiments, the diuretic pump is or includes a syringe pump having a mechanical injector or plunger that is operably coupled to the controller **140**, such that the controller **140** causes movement of the injector to transfer the diuretic to the patient P. The syringe pump can include or be coupled to an actuator that mechanically drives the injector to control the delivery of the diuretic to the patient P. For example, the actuator can be or include a mechanical actuator, such as a nut for rotating a screw to drive the injector. The syringe pump can also include or be operably coupled to a sensor for detecting the position of the injector. Alternatively, or in combination, the diuretic pump can include other types of pumps and/or actuators. For example, the diuretic pump can include a motor, a gearbox operatively connected to the motor, a sensor for measuring rotation of said motor (e.g., a tachometer or an optical encoder), and/or a microcontroller configured to control operation of the motor and monitor the quantity of diuretic delivered to the patient P. As another example, the diuretic pump can include an electric motor, such as a rotary motor, a linear motor, and/or a series of electrically actuated solenoids configured to propel liquid from the diuretic source **134** and through the line **139** toward the patient P.

[0041] In some embodiments, the diuretic components **136** include one or more diuretic sensors configured to determine an amount and/or rate of diuretic flowing toward the patient P. The one or more diuretic sensors can include, for example, a flow sensor, weight sensor, and/or other sensor type configured to determine the amount and/or rate of diuretic delivered from the diuretic source **134**. Optionally, the diuretic sensors can measure diuretic delivery based on the output from the diuretic pump, such as by monitoring the pumping rate (e.g., number of rotations of the diuretic pump per minute, plunger position, and/or combinations thereof). The diuretic components **136** can include additional functional components, such as an air bubble detector, pressure sensor, extravasation sensor (e.g., ivWatch device), and/or other embedded electronics, e.g., to provide feedback signals to the controller **140** to ensure accurate diuretic infusion and/or monitor infusion status.

[0042] The controller **140** is configured to automatically control hydration fluid and/or diuretic infusion (e.g., based at least in part on the patient's urine output) to promote safe and effective diuresis and/or natriuresis (e.g., sodium output) of the patient P. The controller **140** can include one or more processor(s) and tangible, non-transient memory configured to store programmable instructions. The controller **140** can be operably coupled to the urine system **110**, hydration

system **120** and/or diuretic system **130** to receive data (e.g., sensor data) from and transmit data (e.g., control signals) to the various components of these systems. For example, the controller **140** can receive sensor data from the urine system **110** (e.g., from sensor(s) **114**) to determine and/or monitor the patient's urine output. Based on the urine output, the controller **140** can determine an appropriate diuretic dosage amount and/or rate to administer to the patient P, and can cause the diuretic system **130** to deliver the diuretic accordingly. For example, the controller **140** can determine a pumping rate of the diuretic pump to produce the desired delivery profile for the diuretic. Similarly, the controller **140** can determine an appropriate hydration fluid infusion rate for the patient P (e.g., based on the urine output, the diuretic dosage rate, and/or the urine sodium concentration), and can cause the hydration system **120** to deliver the appropriate hydration fluid amount and/or rate. For example, the controller **140** can determine a pumping rate for the hydration fluid pump **126** to achieve the desired hydration fluid infusion rate. The controller **140** can regulate the diuretic dosage rate and/or hydration fluid infusion rates based on a suitable treatment regimen protocol, e.g., prescribed by a physician and/or managed by the controller **140**.

**[0043]** During the procedure, the controller **140** can receive sensor data from the various sensors of the urine system **110**, hydration system **120** and/or diuretic system **130** to monitor the urine output, hydration fluid infusion rate, and/or diuretic dosage rate, respectively. The controller **140** can also receive sensor data from additional sensors configured to monitor patient status and/or operational status of the system **100**, such as fluid pressure sensors, blood pressure sensors, air bubble detectors, analyte detectors, urine conductivity sensors, and the like. For example, the controller **140** can be operably coupled to at least one sensor implanted in, attached to, or otherwise associated with the patient P. The sensor(s) can provide data regarding any of the following patient parameters: pressure levels (e.g., pulmonary artery pressure, left atrial pressure), bioelectric measurements (e.g., bioimpedance vector analysis (BIVA)), hemoglobin measurements (e.g., non-invasive hemoglobin measurements), urine oxygenation levels, urine composition (e.g., creatinine, sodium, potassium, chloride, and/or combinations thereof), urine temperature, body temperature (e.g., bladder temperature), oral fluid intake, heart rate, heart rate variability, blood oxygenation, hematocrit, hemodynamic data, and any other data described herein. The controller **140** can use the data from any of the sensors described herein to monitor treatment progress (e.g., whether the treatment is complete), patient status (e.g., whether the patient is responding well or poorly to treatment), adjust one or more parameters of the fluid therapy (e.g., increase or decrease the hydration fluid infusion rate and/or the diuretic dosage rate) and/or potential safety concerns (e.g., whether the diuresis is too aggressive, whether the patient is exhibiting side effects). The controller **140** can also adjust the hydration fluid infusion rate and/or diuretic dosage rate based on the sensor data. Additionally, the sensor data can also provide feedback to the controller **140** to confirm or verify the effectiveness of the fluid therapy.

**[0044]** The controller **140** can also use other data for monitoring and/or controlling the therapy, such as settings for the system **100**, user input, data indicative of a desired treatment regimen (e.g., a programmed diuretic and/or hydration fluid delivery profile over time), and/or other data

collected or calculated by the controller **140**. In some embodiments, the data used by the controller **140** includes current and/or historical data for the patient P, such as diuretic dosages delivered to the patient P, urine output volume or rate, the amount of hydration fluid infused into the patient P, the weight or change in weight of the patient P at various times during the infusion of the diuretic, indicators of the patient's renal function (e.g., estimated glomerular Filtration Rate (eGFR)), and/or the time(s) during which the patient P was treated with the system **100**. Additionally, or alternatively, the data used by the controller **140** can include historical data for one or more other patients, as described elsewhere herein.

**[0045]** The display **150** (e.g., a touchscreen, monitor, and/or one or more other display devices) can include a user interface configured to receive inputs from the user and display outputs to the user. In some embodiments, the display **150** is operatively coupled to the controller **140** and thus can be used to receive user input indicating treatment parameters, such as parameters for urine output, hydration fluid infusion, and/or diuretic dosage. The treatment parameters can include, for example: a desired fluid balance level (e.g., a positive, negative, or neutral fluid balance), estimated excess fluid volume, target fluid removal volume (e.g., minimum and/or maximum amount of fluid to be removed), desired urine output level (e.g., a total amount of urine output; a target maximum, minimum, and/or average urine output rate), treatment duration (e.g., maximum and/or minimum duration of the treatment procedure; planned duration of the input balance level and/or urine output level), hydration fluid type, hydration fluid infusion rate (e.g., maximum, minimum, and/or average infusion rate), hydration fluid infusion profile (e.g., a function indicating how the amount and/or rate of hydration fluid infusion should vary over time), time limits associated with hydration fluid infusion (e.g., maximum and/or minimum time period for hydration fluid infusion), diuretic type, diuretic dosage (e.g., maximum and/or minimum dosage), diuretic dosage rate (e.g., maximum, minimum, and/or average dosage rate), diuretic dosage profile (e.g., a function indicating how the dosage amount and/or dosage rate of diuretic should vary over time), time limits associated with diuretic delivery (e.g., maximum and/or minimum time period for diuretic delivery), other fluids received by the patient during the procedure (e.g., volume of ingested fluid, volume of fluid from other medical agents besides the diuretic and/or hydration fluid), and/or suitable combinations thereof. Other patient-related inputs may also be received at the display **150** and can include, for example, the patient's sex, weight (e.g., "dry" weight), age, ethnicity, clinical state (e.g., renal function parameters, electrolyte levels such as serum chloride levels), medical history (e.g., outcomes of previous fluid removal procedures, prior response to fluid therapy, and/or combinations thereof), diagnoses (e.g., ADHF, CHF), medications (e.g., whether the patient is diuretic-naïve or diuretic-resistant), dietary factors (e.g., whether the patient is consuming a high-salt or low-salt diet, amount of oral fluid intake), and/or combinations thereof.

**[0046]** Alternatively, or in combination, the user input via the display **150** can prompt the controller **140** to retrieve treatment parameters (e.g., maximum diuretic dosage, maximum continuous diuretic dosage, and minimum desired urine rate) from tables and/or other data sources. The data sources can be stored in the system **100** (e.g., in a memory

associated with the controller **140**) and/or can be stored in a separate device (e.g., a remote computing device). In some embodiments, the controller **140** retrieves data from a remote database and/or server via a communication network (e.g., a wired network, a wireless network, a cloud-based network, the Internet, and/or suitable combinations thereof). In such embodiments, the controller **140** can be operably coupled to a communication device and/or interface configured to transmit and receive data via the communication network.

**[0047]** The controller **140** can output the treatment parameters to the user via the display **150** for review and/or feedback. For example, the display **150** can show recommended treatment parameters for the patient P, such as recommendations for the diuretic, diuretic dosage rate (e.g., initial, maximum, and/or minimum dosage rate), hydration fluid infusion rate (e.g., initial, maximum, and/or minimum infusion rate), urine output rate (e.g., measured urine output rate, sodium-adjusted urine output rate, maximum and/or minimum output rate), sodium and/or other electrolyte output rate, treatment duration (e.g., maximum time period for diuretic and/or hydration fluid infusion; maximum total treatment duration), treatment escalation (e.g., thiazide, temporarily increased fluid matching, additional loop diuretic), end of treatment, and so on. As another example, the display **150** can output one or more predetermined treatment programs so the user can select the appropriate program for the particular patient P. Optionally, the user can modify any of the displayed treatment parameters, if desired.

**[0048]** During the treatment procedure, the controller **140** can output information regarding procedure status to the user via the display **150**. For example, the controller **140** can display information regarding any of the following: urine output (e.g., current urine output rate and/or amount, urine output rate and/or amount over time, total amount of urine output so far), hydration fluid infusion (e.g., current infusion rate and/or amount, infusion rate and/or amount over time, total amount of hydration fluid infused so far), diuretic delivery (e.g., current dosage rate and/or amount, dosage rate and/or amount over time, total amount of diuretic delivered so far), fluid balance (e.g., current fluid balance, fluid balance over time, net fluid removal so far), system status (e.g., amount of hydration fluid remaining in the fluid source **122**, amount of diuretic remaining in the diuretic source **134**, remaining storage capacity in the container **112**), treatment time (e.g., treatment start time, projected and/or planned treatment end time, total treatment duration so far), notifications (e.g., alerts, alarms, messages, recommendations, predictions, error messages), and the like. The user can review the displayed information, and, if appropriate, provide input instructing the controller **140** to adjust, pause, and/or stop the treatment procedure.

**[0049]** In some embodiments, the system **100** includes redundancy in the urine system **110**, hydration system **120**, and/or diuretic system **130** to reduce or minimize treatment interruptions, e.g., due to running out of urine collection capacity, running out of hydration fluid, and/or running out of diuretic. For example, the system **100** can include redundant components (e.g., containers **112**, fluid sources **122**, and/or diuretic sources **134**), which can be stored at predetermined locations (e.g., on or within the console **105** or another portion of the system **100**). The controller **140** can be configured to detect the presence of the redundant components and can automatically or semi-automatically switch

between these components so the treatment procedure can continue uninterrupted or substantially uninterrupted. Alternatively, or in combination, the system **100** can adjust the timing of user alerts related to urine collection capacity, hydration fluid levels, and/or diuretic levels, based on the availability of redundant components. For example, if redundant components are available, the system **100** can generate alerts at a later time (e.g., closer in time to when the container **112** would be full, when the fluid source **122** would be empty, and/or when the diuretic source **134** would be empty), since the system **100** can automatically switch to using the redundant components, or the user can rapidly perform the switch using the redundant components that are already stored locally at the system **100**, rather than having to retrieve replacements from another location.

**[0050]** The lack of interruption in fluid therapy can help ensure effectiveness of the fluid therapy, e.g., by relieving the patient's fluid overload condition as quickly and safely as possible. In some embodiments, even brief interruptions in diuretic delivery and/or hydration fluid infusion can significantly affect the patient's urine output (e.g., cause the urine output rate to drop), which can interfere with therapeutic efficacy and prolong treatment time. The concerns described above regarding diuretic and/or hydration fluid backup supply may be unique to the present technology, e.g., due to the relatively large amounts of diuretic and/or hydration fluid that are utilized over time in some embodiments of the treatment procedures described herein. That is, whereas conventional systems and methods may utilize just a single diuretic source and/or a single hydration fluid source because of the relatively low amount of diuretic and/or hydration fluid administered, the present technology may benefit from multiple diuretic sources and/or hydration fluid sources to ensure treatment continuity. Similarly, the treatment procedures of the present technology can cause the patient P to produce relatively large volumes and/or rates of urine output compared to conventional procedures, such that multiple containers **112** may be helpful to reduce the number of times the user has to empty and/or replace the containers **112** during the procedure.

**[0051]** For example, in some embodiments, the urine system **110** includes two or more redundant containers **112** to ensure fluid therapy does not need to be stopped or interrupted due to the container **112** being full. In such embodiments, the urine system **110** can include a flow control assembly **116** (e.g., valves and/or other flow control components) operably coupled to the controller **140** and configured to selectively direct the urine from the patient P to one or more of the containers **112**. The flow control assembly **116** can initially direct the urine received from the patient P to a first container **112**. Once the flow control assembly **116** detects or determines the first container is full or nearly full (e.g., based on sensor data from the sensor(s) **114**), the flow control assembly **116** can redirect the urine received from the patient P to a second container **112**. While urine is being directed to the second container **112**, a user can empty the first container **112** or replace the first container **112** with an empty container **112**. The flow control assembly **116** and/or controller **140** can generate an alert to the user to indicate the first container is full and needs to be replaced or emptied. This process can be repeated such that fluid management therapy is not inadvertently interrupted due to the containers **112** being full and/or the urine system **110** being unable to accept urine output. In some embodi-

ments, the treatment procedures described herein result in relatively large amounts and/or rates of urine output (e.g., compared to conventional therapies), such that automatic switching between multiple urine containers is advantageous to minimize treatment interruptions.

**[0052]** As another example, the hydration system **120** can include multiple redundant hydration fluid sources **122**, e.g., to ensure the hydration fluid infusion can continue without interruption for the entirety of a therapy session and/or to provide an additional time window for switching hydration fluid sources **122** without interrupting hydration fluid infusion. In such embodiments, the hydration system **120** can include a hydration control assembly (e.g., valves and/or other flow control components—not shown) operably coupled to the controller **140** and configured to switch the source of hydration fluid from a first fluid source **122** to a second fluid source **122**. In such embodiments, the hydration control assembly can initially deliver hydration fluid from the first fluid source **122** to the patient P. The hydration control assembly can monitor whether the first fluid source **122** is empty or nearly empty, e.g., based on data from the fluid sensor **128** and/or other sensors associated with the hydration system **120**. Once the hydration control assembly detects or determines the first fluid source **122** is empty or nearly empty (e.g., the remaining amount of hydration fluid is below a predetermined threshold), the hydration control assembly can switch to delivering hydration fluid from the second source **122**. The switching process can be repeated such that fluid therapy is not inadvertently interrupted due to the fluid source **122** being empty and/or the hydration system **120** being unable to provide hydration fluid.

**[0053]** The process of switching the hydration fluid source **122** can be performed automatically, semi-automatically, or manually. In some embodiments, semi-automatic or manual switching between the first and second fluid sources **122** may be beneficial to ensure the hydration system **120** does not automatically infuse hydration fluid without user confirmation. In such embodiments, the hydration control assembly and/or controller **140** can output an alert asking the user to verify that the hydration fluid should be switched from the first fluid source **122** to the second fluid source **122**. Upon switching to the second fluid source **122**, the controller **140** can generate an alert to the user to indicate the first fluid source **122** is empty and needs to be replaced. Optionally, the hydration control assembly and/or controller **140** can implement a pre-approval procedure in which the user allows the hydration system **120** to automatically infuse a specified volume of additional hydration fluid. Once that volume has been delivered to the patient P, the user may need to provide re-approval before further automatic infusion of hydration fluid.

**[0054]** In some embodiments, the different fluid sources **122** of the hydration system **120** each provide the same type of hydration fluid. In other embodiments, however, some or all of the fluid sources **122** can provide different types of hydration fluid. The hydration fluids can differ from each other with respect to tonicity, composition, electrolyte content, one or more other properties, and/or combinations thereof. Depending on the patient's response to diuresis, the hydration system **120** can deliver multiple different hydration fluids to the patient P sequentially or concurrently. For example, if the patient's urine output indicates that the patient P has an electrolyte imbalance (e.g., a positive sodium balance), the hydration system **120** can switch to

delivering a hydration fluid that would address the imbalance (e.g., a hydration fluid with lower sodium content). The switching can be performed using any of the techniques and/or devices described above. Accordingly, the particular fluid or fluids delivered to the patient P can be tailored to the patient's particular clinical state and/or response to treatment.

**[0055]** In yet another example, the diuretic system **130** can include multiple redundant diuretic sources **134**, e.g., to ensure the diuretic delivery can continue without interruption for the entirety of a therapy session and/or to provide an additional time window for switching diuretic sources **134** without interrupting diuretic delivery. For example, if a first diuretic source **134** (e.g., a first syringe or container) is spent, the diuretic can continue to be supplied (e.g., without substantial interruption) via a second diuretic source **134** (e.g., a second syringe or container). The second diuretic source **134** can be connected to the console **105** and can be operably coupled to a sensor configured to detect the presence of the second diuretic source **134** (e.g., a location sensor, optical sensor, weight sensor, one or more other sensors, and/or combinations thereof). Accordingly, the diuretic system **130** can switch to the second diuretic source **134** if the first diuretic source **134** is empty or nearly empty, and the second diuretic source **134** is present.

**[0056]** In some embodiments, the diuretic system **130** includes two independent diuretic pumps each including its own diuretic source **134**. For example, the diuretic system **130** can include syringe pumps each fluidly coupled to its own syringe filled with diuretic. In some cases, such syringes may only be filled by pharmacists or other health care professionals, and thus may not be readily replaced (e.g., in less than a few hours) by the user. When the diuretic system **130** and/or controller **140** detects that the first diuretic source **134** is empty or nearly empty (e.g., below a predetermined threshold), the diuretic supply can be switched (e.g., automatically or manually) to a second diuretic source **134**. The switching process can include stopping a first syringe pump fluidly coupled to the first syringe, and starting a second syringe pump fluidly coupled to the second syringe. In other embodiments, the diuretic system **130** includes a single diuretic pump (e.g., syringe pump) connected to two diuretic sources **134**. In such embodiments, case switching between the first and second diuretic sources **134** can involve using a diuretic control assembly (e.g., valves and/or other flow control components) to switch the diuretic pump from delivering diuretic from the first diuretic source **134** to the second diuretic source **134**. The switching process can be repeated such that fluid therapy is not inadvertently interrupted due to the diuretic source **134** being empty and/or the diuretic system **130** being unable to provide diuretic.

**[0057]** The process of switching the diuretic source **134** can be performed automatically, semi-automatically, or manually. In some embodiments, manual or semi-automatic switching between the first and second diuretic sources **134** may be beneficial to ensure the diuretic system **130** does not automatically infuse a large volume of diuretic without user confirmation. In such embodiments, the controller **140** can output an alert asking the user to verify that the diuretic should be switched from the first diuretic source **134** to the second diuretic source **134**. Upon switching to the second diuretic source **134**, the controller **140** can generate an alert to the user to indicate the first diuretic source **134** is empty



and needs to be replaced. Optionally, the controller **140** can predict a time point and/or time range when the first diuretic source **134** will be empty (e.g., based on the diuretic dosage rate), and can output a notification so the user can order or otherwise prepare a replacement diuretic source **134** before the first diuretic source **134** runs out. Moreover, the diuretic control assembly and/or controller **140** can implement a pre-approval procedure in which the user allows the diuretic system **130** to automatically deliver a specified additional dosage of diuretic. Once that dosage has been delivered to the patient P, the user may need to provide re-approval before further automatic delivery of diuretic.

**[0058]** In some embodiments, the different diuretic sources **134** of the diuretic system **130** each provide the same type of diuretic. In other embodiments, however, some or all of the diuretic sources **134** can provide different types of diuretics. Depending on the patient's response to diuresis, the diuretic system **130** can deliver multiple different diuretics to the patient P sequentially or concurrently. For example, the diuretic system **130** can initially deliver a first diuretic to the patient P from a first diuretic source **134**. If the patient P responds poorly to the first diuretic (e.g., the urine output rate does not increase or increases very slowly), the diuretic system **130** can switch to delivering a second, different diuretic from a second diuretic source **134**. The diuretic system **130** can continue delivering the first diuretic concurrently with the second diuretic or can terminate delivery of the first diuretic when the second diuretic is delivered. The switching can be performed using any of the techniques and/or devices described above. As another example, if the patient P does not respond well to a single diuretic, the diuretic system **130** can simultaneously administer multiple diuretics to the patient P. The ratio of the different diuretics can be varied as appropriate to elicit a suitable urine output rate. In other embodiments, however, rather than automatically administering additional diuretics, the diuretic system **130** can output a notification recommending that the user manually administer a different diuretic to the patient P and/or requesting that the user approve administration of a different diuretic, which may be beneficial for patient safety. Without being bound by theory, some diuretics are absorbed at a proximal end of the kidney and other diuretics are absorbed at a distal end of the kidney and using combinations of diuretics that are absorbed at the proximal and distal ends can be effective for improving overall fluid therapy.

**[0059]** The system **100** illustrated in FIG. 1 can be configured in many different ways. For example, the locations of the various components of the system **100** can be altered, e.g., the urine system **110**, hydration system **120**, and/or diuretic system **130** can be at different locations in the console **105**. As another example, any one of the urine system **110**, hydration system **120**, or diuretic system **130** can be part of a separate system or device (e.g., a separate console), or can be omitted altogether. For instance, in some embodiments, the urine system **110** is replaced with a mechanism for monitoring the patient's urine output that does not require the catheter **118** and/or urine collection, such as one or more ultrasound sensors that measures the patient's bladder volume. The ultrasound sensor can be implemented as a patch or similar device that is coupled to the patient's body. The controller **140** can process the ultrasound sensor data to detect changes in the bladder volume and can determine the corresponding amount and/or

rate of urine output based on the bladder volume. The use of non-invasive urine monitoring mechanisms such as an ultrasound sensor can allow the treatment procedures described herein to be performed in outpatient settings.

**[0060]** As another example, in some embodiments, the hydration system **120** is omitted such that diuresis is performed without hydration fluid infusion, or the hydration fluid is infused manually. Diuresis with hydration fluid infusion may be more beneficial for patients with low serum chloride levels (e.g., patients with low-salt diets), while patient with high serum chloride levels (e.g., patients with high-salt diets) may tolerate diuresis with little or no hydration fluid infusion. Optionally, the hydration fluid infusion rate can be varied at least partially based on the patient's serum chloride levels, e.g., lower amounts and/or rates of hydration fluid infusion can be used if the patient's serum chloride level is high (e.g., greater than or equal to 105 mmol/L).

**[0061]** In yet another example, the diuretic system **130** can be omitted such that no diuresis is performed, or the diuresis is performed manually. In such embodiments, the system **100** can provide automated fluid replacement via the hydration system **120** and/or can automatically monitor the patient's urine output via the urine system **110**, but the diuretic would be administered manually by a healthcare professional in accordance with techniques known to those of skill in the art.

**[0062]** The system **100** can optionally include or be used in combination with additional systems or devices, such as systems or devices configured to perform any the following functions: administering other medications and/or agents besides the diuretic and hydration fluid (e.g., heart failure medication), monitoring other patient parameters besides urine output (e.g., blood pressure, weight, heart rate, blood oxygenation, respiratory rate, temperature), and/or performing other types of medical procedures on the patient P concurrently or sequentially with the fluid removal procedure (e.g., dialysis, ultrafiltration).

**[0063]** In some embodiments, the system **100** includes a platform **160** and the patient P, the patient's belongings (e.g., such as the patient's mobile phone **170**), food, drink, clothing, the bed or other furniture upon which the patient resides, and/or other objects used by the patient during fluid therapy can be placed on the platform **160** during fluid therapy. As shown in FIG. 1, the console **105** can be positioned elsewhere, e.g., not on the platform **160**. The platform **160** can include a weight sensor and/or be otherwise configured to obtain a weight (or a change in weight) of the objects positioned on the platform **160**. If the patient P does not utilize a catheter **118** (e.g., a foley or other catheter), the patient P can be instructed to remain on the platform **160** except when urinating and, accordingly, changes in the weight obtained by the platform can correspond to the patient's urine output. If the patient has bowel movements, vomits, and/or takes one or more other actions besides urinating that may affect the patient's weight when off the platform, changes in weight (or estimations thereof) associated with these actions can be input into the system **100**.

**[0064]** In some embodiments, one or more external sensors **180** can be disposed on the patient P and/or otherwise positioned to measure a dimension of one or more of the patient's organs. For example, the one or more external sensors **180** can be positioned to measure a volume (or change in volume) of the patient's bladder, and/or a volume

(or change in volume) of urine contained within the patient's bladder. Data from the one or more external sensors **180** can be used to determine a urine output of the patient. The one or more external sensors **180** can include an ultrasonic sensor, a magnetic resonance imaging (MRI) sensor, a bioimpedance sensor (e.g., an electrical impedance tomography (EIT) sensor) a radar sensor, a computed tomography (CT) sensor, and/or one or more other suitable sensors, including any other sensors described herein. When the one or more external sensors **180** are worn/disposed on the patient P, the patient P can be instructed to minimize movement, avoid fluid intake, or take other measures that may affect the accuracy of the one or more external sensors **180**.

[0065] FIG. 2 is a flow diagram of a method **200** for treating a patient, in accordance with embodiments of the present technology. In some embodiments, the method **200** is used to treat the patient for fluid overload by removing fluid from the patient to produce a negative fluid balance (net fluid loss). The method **200** can be performed by any embodiment of the systems and devices described herein, such as the system **100** of FIG. 1. In some embodiments, some or all of the blocks of the method **200** are performed by a system or device including one or more processors and a memory storing instructions that, when executed by the one or more processors, cause the system or device to perform one or more of the blocks described herein. For example, the method **200** can be performed by the controller **140** of the system **100** of FIG. 1, CPU **341** of FIG. 3B, and/or another suitable processor. Optionally, some or all of the blocks of the method **200** can be performed automatically or semi-automatically, with little or no human intervention.

[0066] The method **200** can begin at block **202** with obtaining a urine output rate from a patient. In some embodiments, obtaining the urine output rate can include obtaining the urine output rate via a urine monitoring and/or collection system connected to the patient, such as the urine system **110** of FIG. 1. The urine monitoring and/or collection system can, for example, determine the urine output rate based at least partially on one or more received inputs of urine output data, such as data obtained via one or more sensors (e.g., the sensor(s) **114** of FIG. 1) configured to measure the urine output rate based on flow rate, weight (e.g., of the container **112** of FIG. 1), volume, fluid level, and/or any other suitable parameter. The urine output rate can be calculated based on the received input, e.g., by a controller (e.g., controller **140** of FIG. 1) operatively coupled to the sensor(s). The urine output rate can be a current rate or an average rate measured over a predetermined time period (e.g., the previous 5 or 10 minutes). The urine output rate can be updated on a continuous or recurring basis (e.g., every 30 seconds, 1 minutes, 2 minutes, and/or combinations thereof). In at least some embodiments, obtaining the urine output rate can include obtaining the urine output rate without using an indwelling catheter. In some embodiments, the process of block **202** is performed concurrently with some or all of the other blocks of the method **200** (e.g., blocks **204**, **206**, and/or **208**) to provide continuous or substantially continuous urine output monitoring through the entirety of the method **200**.

[0067] In some embodiments, one or more of the sensors can be disposed on the patient and/or otherwise positioned to measure a dimension of an organ of the patient and block **202** can include obtaining the urine output rate based at least

partially on the measured dimension of the organ. For example, the one or more sensors can include one or more of the external sensors **180** (FIG. 1) which, as described elsewhere herein, can be positioned to measure a volume (or change in volume) of the patient's bladder and/or a volume (or change in volume) of urine contained within the patient's bladder, including volumes/changes associated with urination by the patient. In some embodiments, obtaining the urine output rate via one or more of the external sensors includes obtaining the urine output rate during (e.g., only during) the diuretic dose finding phase of fluid therapy and, at one or more other times during fluid therapy (e.g., during the continuous delivery phase), the one or more external sensors **180** can be removed from the patient and obtaining the urine output rate can include obtaining the urine output rate based at least partially on urine received via a non-indwelling catheter as described further below and/or via one or more other devices configured to measure the patient's urine output, such as the platform **160** (FIG. 1).

[0068] At block **204**, the method **200** optionally continues with causing a diuretic to be provided to the patient at a dosage rate. The diuretic can be or include furosemide, bumetanide, ethacrynic acid, torsemide, combinations thereof, and/or other diuretics known in the art. In some embodiment, the diuretic is delivered as part of a solution including saline or other hydration fluid(s) mixed therewith. The diuretic can be provided automatically or semi-automatically by a diuretic system connected to the patient, such as the diuretic system **130** of FIG. 1. The diuretic system can be operably coupled to a controller (e.g., controller **140** of FIG. 1) for causing diuretic delivery in accordance with a planned and/or pre-programmed treatment procedure.

[0069] In some embodiments, the treatment procedure includes multiple phases, and each phase is associated with a different delivery profile for the diuretic. In such embodiments, block **204** can be performed as part of an initial phase to determine an appropriate diuretic dosage rate for treating the patient (also known as a "dosage determining phase"). In the dosage determining phase, the diuretic is injected at an initial dosage rate, and the dosage rate can then be gradually increased (e.g., "ramped") to elicit an increase in the patient's urine output rate. The diuretic dosage rate can be increased according to a desired function or delivery profile, such as a continuous function, a block-wise function, or a combination thereof). The function can include iteratively increasing the dosage rate linearly, exponentially, according to a polynomial function, and/or any other suitable ramp function or profile. In some embodiments, the diuretic is delivered in a manner such that a subsequent dosage rate is a predetermined percentage (e.g., at least 5%, 10%, 15%, 25%, and/or combinations thereof) above the immediately previous dosage rate. The predetermined percentage can increase or decrease over time, e.g., depending on the desired fluid therapy and/or patient considerations. Optionally, the diuretic can be provided in a manner that doubles the diuretic dosage rate or total diuretic within a period of time (e.g., 10 minutes, 15 minutes, 20 minutes, or within a range of 10-20 minutes). In other embodiments, however, the dosage determining phase can include one or more time periods during which the diuretic dosage rate does not increase and/or is held substantially constant. The dosage determining phase can continue until the patient's urine output reaches or exceeds a desired threshold rate and/or a predetermined time period has elapsed, at which point the

diuretic dosage rate can be adjusted, as described in block **208** below. Additional details regarding administering diuretic to the patient are described with reference to at least FIG. 4A of U.S. Pat. No. 11,357,446, the entirety of which is hereby incorporated herein by reference.

[**0070**] At block **206**, the method **200** can optionally include causing a hydration fluid to be provided to the patient at a hydration rate. The hydration fluid can comprise saline and/or other fluids having sodium and can be provided automatically or semi-automatically by a hydration fluid system connected to the patient, such as the hydration system **120** of FIG. **1**. The hydration fluid can be provided before, during, and/or after providing the diuretic in block **204** (e.g., before, during, and/or after the dosage determining phase). Intravenous infusion of hydration fluid containing electrolytes (e.g., sodium and/or chloride) can increase diuretic efficiency, which is counterintuitive since a goal of fluid therapy is net removal of fluid. Hydration fluid can also reduce or inhibit intravascular depletion, decreases in cardiac output, and/or decreases in renal perfusion, among other benefits.

[**0071**] In some embodiments, the hydration fluid is provided to the patient based at least in part on the patient's urine output rate, e.g., to drive net fluid loss from the patient. For example, the hydration rate can be less than the urine output rate. In some embodiments, the hydration rate is a percentage of the urine output rate (e.g., 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, or 10% of the urine output rate) for a given range of urine output rates (e.g., from 0 ml/hr to 1000 ml/hr). Optionally, the percentage can be higher for certain parts of the range (e.g., for the lower end of the range to reduce the likelihood of hypotension) and/or lower for other parts of the range (e.g., for the higher end of the range to increase net fluid loss). As another example, the hydration rate can substantially match the urine output rate (e.g., 100% of the urine output rate) for an initial amount of urine output by the patient (e.g., at least the initial 150 milliliters (mL), 200 mL, or 250 mL), for an initial time period (e.g., the first hour, 2 hours, or 3 hours), for an initial time period during hydration fluid and/or diuretic dose finding, and/or until the patient's urine output rate reaches a predetermined threshold. Subsequently, the hydration rate can be adjusted to be less than the urine output rate. In a further example, the hydration rate may be determined based on whether the urine output rate is above or below one or more different thresholds, with the difference between the urine output rate and hydration fluid rate increasing as the urine output rate increases. In such embodiments, the difference between the urine output rate and the hydration fluid rate can increase (with the urine rate being higher than the hydration fluid rate) as the urine output rate increases, and thus the net fluid loss from the patient can increase as the urine output rate increases.

[**0072**] At block **208**, the method **200** can include adjusting at least one of the dosage rate of the diuretic or the hydration rate of the hydration fluid, thereby causing net fluid loss from the patient. For example, the (i) diuretic dosage rate can be adjusted, (ii) the hydration rate can be adjusted, or (iii) the diuretic dosage rate and the hydration rate can both be adjusted. In some embodiments, the diuretic dosage rate is adjusted after the dosage determining phase of the treatment procedure is complete. As discussed above in block **204**, the dosage determining phase can end when (i) a predetermined amount of time has elapsed since the initial

diuretic administration, and/or (ii) the urine output rate is or becomes greater than or equal to a predetermined threshold rate. The treatment procedure can then switch to a phase in which the diuretic dosage rate is adjusted to a dosage rate configured to maintain the patient's urine output rate at or above a desired output rate to cause net fluid loss (also known as a "continuous delivery phase" or "fluid reduction phase").

[**0073**] The adjusted diuretic dosage rate can be the initial dosage rate for the fluid reduction phase and can be determined in many different ways. For example, the adjusted diuretic dosage rate can be based on the outcome of the dosage determining phase (e.g., the dosage rate when the patient's urine output reaches or exceeds the target threshold). In representative embodiments, the diuretic dosage rate is decreased, e.g., to maintain the patient's urine output rate at a predetermined rate and/or within a predetermined range (e.g., no more than 5%, 10%, or 20% variability from a predetermined rate). Decreasing the diuretic dosage rate can decrease the rate of increase in urine output rate (e.g., cause the patient's urine output to approach a constant or substantially constant rate) but without actually decreasing the urine output rate itself.

[**0074**] In some embodiments, the adjusted diuretic dosage rate is a predetermined percentage or fraction of the current dosage rate (e.g., the dosage rate at the end of the dosage determining phase) or a predetermined percentage of the cumulative diuretic dosage amount (e.g., the cumulative amount delivered during the dosage determining phase). For example, the adjusted dosage rate can be a predetermined percentage (e.g., 10%, 15%, 20%, 25%, 30%, or within a range of 10-30%) of a value of the total amount of diuretic delivered to the patient at that time. For example, if the total amount delivered is 100 mg, and the predetermined percentage is 25%, then the adjusted dosage rate can be 25 mg/hr. In some embodiments, the percentage used to calculate the adjusted diuretic dosage rate is based on a pharmacokinetic characteristic of the particular diuretic being infused. For example, the percentage can be 20% for furosemide, such that if 50 mg of furosemide is infused in 60 minutes, then the adjusted diuretic dosage rate can be 10 mg/hr.

[**0075**] In some embodiments, block **208** includes delivering the diuretic at the adjusted diuretic dosage rate until the fluid reduction phase is complete, e.g., until a predetermined period of time has elapsed, the patient's urine output drops below a low urine output threshold, and/or until a target net fluid loss volume is achieved. During the fluid reduction phase, the diuretic dosage rate can be constant or substantially constant (e.g., no more than 5%, 10%, or 20% variability from the initially determined adjusted diuretic dosage rate). In other embodiments, however, block **208** can include making additional adjustments to the diuretic dosage rate during the treatment procedure (e.g., increasing and/or decreasing the diuretic dosage rate). The adjustments can be based on whether one or more of a predetermined set of conditions is met, such as whether the urine output rate is too high (e.g., which can indicate that the patient has a high and/or increasing serum level of diuretic). The set of conditions can include (i) an average urine rate being greater than a predetermined rate for a period of time, (ii) an average rate of change of the urine rate being greater than a predetermined rate of change, and/or (iii) a diuretic dosage rate being greater than a predetermined dosage rate. If some (e.g., two) or all of the conditions are met, the diuretic

dosage rate can be decreased (e.g., by a predetermined amount or percentage), also referred to herein as “down-titration.”

**[0076]** In some embodiments, a down-titration is performed only if all or a majority of the above conditions are met, which can avoid unnecessarily decreasing the diuretic dosage rate, thereby allowing urine output rates to remain high and avoiding unnecessary interruptions to the treatment procedure. For example, whereas other methodologies may interrupt fluid therapy and decrease the diuretic dosage rate (e.g., to zero mg/hr) only when the urine rate too high, the process described herein may only decrease the dosage rate (e.g., to a non-zero or zero dosage rate) when one or more factors are met, such as when the urine output rate is both high and continuing to increase. Stated differently, the process herein can prevent the diuretic dosage rate from being unnecessarily decreased when urine rates are temporarily high (e.g., above the predetermined rate), but are trending downward. This approach can prevent or inhibit over-diuresis, excess fluid loss and/or electrolyte loss, as well limit unnecessary exposure of the patient to additional diuretic. Additionally, because the diuretic dosage rate can be down-titrated, rather than stopping the diuretic entirely, the fluid therapy can continue (albeit at lower urine output rates) without needing to completely restart the procedure.

**[0077]** As another example, the additional adjustments to the diuretic dosage rate in block 208 can include increasing the diuretic dosage rate, also referred to herein as “re-ramping” or “up-titration.” In some embodiments, re-ramping is performed if urine output rates are too low, as determined based on a set of conditions. The set of conditions can include (i) the average urine rate being below a predetermined threshold rate for a predetermined period of time, and/or (ii) more than a predetermined amount of debt has accumulated over the predetermined period of time. “Debt” can be defined as the area on a plot between the urine output rate and a set rate (e.g., 325 ml/hr), and can represent how much of and for how long the urine output rate has been below the set rate. If some or all of the conditions are met, re-ramping can be performed by incrementally increasing the diuretic dosage rate until (i) a predetermined amount of time has elapsed, and/or (ii) the urine output rate is or becomes greater than or equal to a predetermined threshold rate. The re-ramp process can be identical or generally similar to the dosage determining process previously described in block 204. In representative embodiments, the dosage rate or “ramp” can start at any dosage identified during the dosage determining process, such as the current dosage rate, a previously determined dosage rate, or another suitable dosage rate (e.g., not at the beginning of the dosage).

**[0078]** The re-ramping process can be performed automatically, semi-automatically, or manually. In some embodiments, re-ramping is a semi-automatic or manual process requiring user approval, e.g., for regulatory and/or safety reasons. In such embodiments, the system can output a notification to the user (e.g., via the display 150 of FIG. 1) instructing the user to confirm that re-ramping should be initiated. Optionally, the system can implement a pre-approval procedure in which the user can allow the system to automatically perform re-ramping under certain conditions (e.g., within a specific time period, until a certain urine output volume and/or rate is achieved, for a maximum diuretic amount and/or dosage rate, and/or combinations

thereof). This approach can allow for automatic re-ramping under limited circumstances, which can reduce the amount of human intervention during the treatment procedure and improve the responsiveness of the system to the patient’s current state. Once the pre-approval conditions have elapsed, the user may need to provide re-approval before additional automatic re-ramping is allowed.

**[0079]** In some embodiments, block 208 also includes adjusting the diuretic dosage rate in response to a potential and/or detected blockage (e.g., an air lock, a kink in a fluid line, and/or combinations thereof) in the urine collection system. For example, an air lock can be any partial or complete obstruction of fluid flow due to trapped gas (e.g., air) within a fluid system. Air locks may produce an artificial drop in urine output rates, which can affect the determination of the diuretic dosage rate (e.g., result in a diuretic dosage rate that is too high). In some embodiments, the presence of an air lock is detected based on a period of little or no urine output (due to the air lock blocking urine flow), followed by a sudden large bolus of urine output (due to built-up pressure in the fluid line clearing the air lock). When the system detects that an air lock or other blockage was or is present, the system can compensate by adjusting the diuretic dosage rate to the dosage rate that should have been used if the air lock or other blockage had not occurred. The appropriate dosage rate can be determined based on historical data for the patient receiving the fluid therapy and/or one or more other patients (e.g., the diuretic dosage rate before the air lock occurred, a diuretic dosage rate calculated from the patient’s urine output rate before the air lock occurred, and/or combinations thereof).

**[0080]** Alternatively, or in combination, block 208 can include adjusting the hydration rate, e.g., by increasing or decreasing the hydration rate based on the patient’s urine output rate to drive net fluid loss from the patient. For example, as previously described, the hydration rate can initially match the patient’s urine output rate for a set of initial conditions (e.g., certain time period, initial urine output amount, and/or initial urine output rate). Once the initial conditions have elapsed, the hydration rate can be maintained at a rate lower than the urine output rate (e.g., a percentage of the urine output rate) so the patient exhibits net fluid loss during the fluid reduction phase. The hydration rate can be determined in various ways, such as a percentage or fraction of the patient’s urine output rate, based on whether the urine output rate is above or below a number of different thresholds (e.g., with the difference between the urine output rate and hydration rate increasing as the urine output rate increases), and/or any other suitable approach.

**[0081]** Optionally, the diuretic dosage rate and/or hydration rate can be adjusted based on factors other than patient’s urine output rate. For example, the diuretic dosage rate and/or hydration rate can be adjusted based on the patient’s blood pressure in order to avoid placing the patient in a hypotensive state. In some embodiments, if the patient’s blood pressure level is too low (e.g., below a threshold value or range), the system can avoid increasing the diuretic dosage rate and/or can decrease the diuretic dosage rate for a certain period of time. Alternatively, or in combination, the system can increase the hydration rate (e.g., to the maximum allowable hydration rate and/or to provide a desired fluid replacement profile (e.g., a 100% match to the patient’s urine output rate)) for a certain period of time if low blood pressure levels are detected. The system can also output an

alert indicating that the patient's blood pressure level is low so a user can check on the patient's status. Optionally, the system can take both blood pressure levels and urine output rates into account, e.g., the system can generate alerts and/or can adjust the diuretic dosage rate and/or hydration rate if the Patient's blood pressure is low and the patient's urine output rate drops. This approach can improve patient safety and control over the treatment procedure.

**[0082]** In some embodiments, some or all of the blocks of the method **200** are performed as part of a medical procedure for treating the patient for a fluid overload condition. The method **200** can be used as a primary, standalone therapy for treating fluid overload, or can be used in combination with other therapies (e.g., as a post-primary therapy to reduce the likelihood of re-hospitalization). The method **200** can be performed in any suitable setting, such as an inpatient setting or an outpatient setting. In embodiments where the method **200** is performed as an outpatient therapy, the overall duration of the method **200** can be reduced (e.g., to no more than 10 hours, 8 hours, 5 hours, 4 hours, 3 hours, 2 hours, or 1 hour).

**[0083]** The method **200** illustrated in FIG. 2 can be modified in many different ways. For example, any of the blocks of the method **200** can be omitted, such as blocks **204** or **206**. In some embodiments, block **204** is omitted so that the method **200** controls hydration fluid infusion but not diuretic delivery, or so that the method **200** does not involve any diuretic delivery at all. Similarly, block **206** can be omitted so that the method **200** controls diuretic delivery but not hydration fluid infusion, or so that the method **200** does not involve any hydration fluid infusion at all. As another example, some or all of the blocks **200** of the method **200** can be performed in a different order and/or repeated (e.g., any of blocks **202**, **204**, **206**, and/or **208**). In a further example, the method **200** can optionally include additional blocks not shown in FIG. 2 (e.g., causing delivery of additional medications, obtaining parameters other than urine output rate, and/or combinations thereof).

**[0084]** The present technology can provide many advantages for treating fluid overload and/or managing patient fluid levels. For example, embodiments of the present technology have been shown to consistently reduce the fluid volume in patients faster and safer than conventional treatment systems and methods. For example, whereas conventional methods can typically take at least five days to remove 4-5 L of net fluid volume, embodiments of the present technology have been shown to remove 4-5 L liters of net fluid volume in no more than 24 hours. Additionally, embodiments of the present technology have also been shown to remove significant amounts of salt via high sodium urine from patients. This can reduce the likelihood of the patient reaccumulating fluid after discharge, which can lead to reductions in rehospitalization rates. Moreover, embodiments of the present technology can automatically and continuously monitor urine output, hydration fluid infusion, and/or diuretic delivery to mitigate patient safety concerns (e.g., over-diuresis and/or hypotension) during the treatment procedure.

**[0085]** Embodiments of the present technology can provide various benefits, such as any of the following: (i) optimizing net fluid volume removal; (ii) reducing the time needed to achieve desired net fluid removal by allowing physicians to use higher diuretic dosages and/or dosage rates earlier in treatment compared to conventional treatments;

(iii) avoiding or reducing risk of adverse events such as over-diuresis, dehydration, and/or intravascular depletion; (iv) quickly assessing if a patient is diuretic resistant; and (v) providing a record of treatment data. Embodiments of the present technology may obtain an average net fluid removal rate (e.g., average urine output rate minus average hydration fluid infusion rate) of at least 225 ml/hr, which provides 3.4 L per day of net fluid volume removal based on introducing 2 L of fluid per day orally or through IV infusion. This rate of fluid removal, while replacing sodium, may reduce the overall length of stay and/or provide enhanced decongestion.

### lil. Urine Output Sensing without the Use of an Indwelling Catheter

**[0086]** FIGS. 3A-10 are flowcharts illustrating methods **300**, **310**, **400**, **500**, **600**, **610**, **630**, **650**, **601**, **700**, **800**, **900**, **1000** ("methods **300-1000**") for treating a patient in accordance with embodiments of the present technology. One or more of the methods **300-1000** can be used to treat the patient for fluid overload by removing fluid from the patient to produce a negative fluid balance (i.e., net fluid loss). The methods **300-1000** are described herein as a series of process portions, steps, or blocks, individual ones of which can be performed by any embodiment of the systems and devices described herein, such as the system **100** of FIG. 1. All or a subset of the blocks of one or more of the methods **300-1000** can be performed without using an indwelling catheter, such as while the patient is using a non-indwelling catheter or other non-indwelling device configured to obtain urine output from the patient. In some embodiments, at least some blocks of one or more of the methods **300-1000** are performed by a system or device including one or more processors and a memory storing instructions that, when executed by the one or more processors, cause the system or device to perform one or more of the blocks described herein. For example, one or more of the methods **300-1000** can be performed by the controller **140** of the system **100** of FIG. 1, and/or one or more other suitable computing devices/systems. All or a portion of one or more of the methods described herein can be performed on a single processing device, on multiple processing devices, and/or in a networked or cloud computing environment. Optionally, some or all of the blocks of one or more of the methods can be performed automatically or semi-automatically, with little or no human intervention. Although at least some methods of the present technology are described with reference to measuring individual inputs of a patient's urine output volume data and, e.g., using those data to determine as estimated or average urine output rate for a patient, those of ordinary skill in the art will appreciate that the methods of the present technology can be based, additionally or alternatively, on measuring individual inputs of sodium excretion data (e.g., the sodium concentration of a given input of urine output volume data) and/or an estimated or average sodium excretion rate determined based at least partially on the individual inputs of sodium excretion data.

**[0087]** The method **300** of FIG. 3A is generally associated with providing fluid therapy to a patient. The method **300** can be performed by a fluid therapy system (e.g., the system **100**) configured to provide fluid therapy to patients with an indwelling catheter and to patients with a non-indwelling catheter. Stated differently, the method **300** can allow a fluid therapy system to provide fluid therapy to patients for which

“continuous” or urine output rate data is available (based at least partially on, e.g., urine received via an indwelling catheter) and to patients for which “discontinuous” or urine output volume data is available (based at least partially on, e.g., urine received via a non-indwelling catheter). For example, as set forth below, the method **300** can allow the system **100** to switch between “indwelling” or “Foley” and “non-indwelling” or “no-Foley” modes of operating, e.g., to calibrate the patient’s fluid therapy to the specific equipment used by the patient as part of that fluid therapy and/or the urine output data received from the patient during fluid therapy.

**[0088]** The method **300** can begin at block **302** by obtaining urine output data from a patient without using an indwelling catheter. Block **302** can be at least generally similar or identical to block **202** of the method **200** (FIG. 2), but the obtained urine output data can include urine output volume data (e.g., based at least partially on urine obtained via an external or other non-indwelling catheter) instead of urine output rate data (e.g., which is typically based at least partially on urine obtained via an indwelling catheter). The obtained urine output volume data can be discontinuous. For example, individual inputs of the urine output volume data can correspond to urination (voluntary or otherwise) by the patient, and/or individual inputs of the urine output volume data can be obtained no less than a predetermined amount of time (e.g., no less than 1 second, 5 seconds, 10 seconds, 15 seconds, 30 seconds, 1 minute, 5 minutes, 10 minutes, 20 minutes, 30 minutes, 45 minutes, 1 hour, and/or combinations thereof) apart from one another.

**[0089]** In some embodiments, obtaining the urine output data in block **302** includes obtaining an amount of time since one or more prior inputs of urine output volume data were obtained. The amount of time can be, for example, the total time since the patient most recently urinated (voluntarily or otherwise) and/or the time between individual urinations events. The obtained amount of time can be used to calculate or estimate an average urine output rate over the obtained amount of time, e.g., by dividing the obtained urine output volume data by the obtained amount of time. Additionally, or alternatively, a smoothing function, a curve-fitting function, or other suitable algorithms can be applied to the urine output volume data to estimate urine output rate data.

**[0090]** In block **304**, the method **300** can include determining whether the obtained urine output data (block **302**) equals or exceeds a urine output threshold. Embodiments of the present technology are expected to provide effective fluid therapy and promote net fluid and/or sodium loss from patients that do not use indwelling catheters. However, once a patient’s urine output exceeds a certain volume and/or rate, it may be beneficial to transition those patients to an indwelling catheter to improve (e.g., further improve) or even optimize the patient’s net fluid and/or sodium loss. The urine output threshold can correspond to urine output volume and/or rate at or beyond which it is beneficial to transition a given patient to an indwelling catheter. For example, the urine output threshold can include a volume of urine output (e.g., a volume of at least 50 mL, 100 mL, 150 mL, 200 mL, 500 mL, and/or combinations thereof up to 1 liter (L), 1.5 L, or 2 L). The volume can be associated with a single bolus, multiple boluses, and/or a volume of urine output over a predetermined time period (e.g., up to 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7 hours, 8 hours, and/or combinations thereof). In these and/or other

embodiments, the urine output threshold can include an average rate of urine output, such as an average rate of up to 50 mL/hr, 100 mL/hr, 150 mL/hr, 200 mL/hr, 250 mL/hr, 300 mL/hr, 400 mL/hr, 500 mL/hr, and/or combinations thereof. The average rate of urine output can be an average rate of urine output for the entire duration of the patient’s therapy, a subset thereof, or a predetermined time period (e.g., the last 30 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 5 hours, 6 hours, 7 hours, 8 hours, and/or combinations thereof of the patient’s therapy). If the urine output data is less than the urine output threshold (block **304**, NO), then the method **300** can return to block **302**. If the urine output data equals or exceeds the urine output threshold (block **304**, YES), the method **300** can include block **306**.

**[0091]** At block **306**, the method **300** can include prompting a user to transition the patient to an indwelling catheter. The indwelling catheter can include a Foley catheter. Prompting the user to transition the patient to the indwelling catheter can include receiving confirmation from the patient that the patient wishes to use the indwelling catheter. In some embodiments, the urine output data (block **302**) is being obtained via a non-indwelling catheter, and block **306** includes replacing the non-indwelling catheter with the indwelling catheter. In some embodiments, block **306** can include receiving confirmation that the patient has been transitioned to the indwelling catheter after, e.g., the user has replaced the patient’s non-indwelling catheter with the indwelling catheter.

**[0092]** At block **308**, the method **300** can include changing a fluid therapy system to an indwelling catheter mode. For example, prior to block **308**, the fluid therapy system can obtain urine output data from the patient (block **302**) without using an indwelling catheter and can, accordingly, be operating in a non-indwelling catheter mode, e.g., to account for the inability of the fluid therapy system to accurately measure the patient’s instantaneous urine output rate while the patient is not using an indwelling catheter. When the fluid therapy system is in the indwelling catheter mode, the fluid therapy system can be configured to provide fluid therapy in a manner that is at least generally similar to the method **200** described previously with reference to FIG. 2. Once the patient has been transitioned to the indwelling catheter (block **306**), however, the fluid therapy system can accurately obtain the patient’s instantaneous urine output rate via the indwelling catheter and, accordingly, can be changed to operate in the indwelling catheter mode. Accordingly, in some embodiments, the fluid therapy system can automatically change to the indwelling catheter mode when, for example, the fluid therapy system detects that the obtained urine output data is continuous and/or otherwise associated with urine excretion by the patient’s bladder. In these and/or other embodiments, the fluid therapy system can change to the indwelling catheter mode in response to one or more inputs provided by the user. When the fluid therapy system is in the non-indwelling catheter mode, the fluid therapy system can be configured to provide fluid therapy in a manner that is at least generally similar to one or more of the methods **310**, **400**, **500**, **600**, **610**, **630**, **650**, **601**, **700**, **800**, **900** described below with reference to FIGS. 3B-9. In some embodiments, block **308** can include receiving an input (e.g., from a user) associated with and/or otherwise informing the system that the patient has been or desires to be transitioned to an indwelling catheter.

**[0093]** Although the method **300** is described with reference to transitioning a patient from a non-indwelling catheter to an indwelling catheter, in other embodiments the patient can be transitioned from an indwelling catheter to a non-indwelling catheter. For example, at the start of fluid therapy, an indwelling (e.g., Foley) catheter can be used unless or until the patient experiences one or more adverse events related to the indwelling catheter (e.g., discomfort, pain, flow blockage, infection, and/or combinations thereof) and, in response to the one or more adverse events, the patient can transition to a non-dwelling catheter. Likewise, although the method **300** is described with reference to transitioning a fluid therapy system from a non-indwelling catheter mode to an indwelling catheter mode, in other embodiments the fluid therapy system can be transitioned from an indwelling catheter mode to a non-indwelling catheter mode. For example, at the start of fluid therapy, the patient can use an indwelling (e.g., Foley) catheter and the fluid therapy system can operate in an indwelling catheter mode unless or until the patient experiences one or more adverse events related to the indwelling catheter (e.g., discomfort, pain, flow blockage, infection, and/or combinations thereof) and, in response to the one or more adverse events, the patient can be transitioned to a non-dwelling catheter and the fluid therapy system can, accordingly, be transitioned to a non-indwelling catheter mode. In these and/or other embodiments, one or more of blocks **302-306** can be omitted and the patient can be transitioned to an indwelling catheter, e.g., in response to a physician's recommendation and/or at the patient's request.

**[0094]** The method **310** of FIG. 3B is generally associated with providing fluid therapy to a patient. At block **312**, the method **310** can include obtaining, via one or more sensors, urine output data from the patient. Obtaining the urine output data can include obtaining one or more (e.g., multiple) inputs of urine output volume data. Obtaining the multiple inputs can include obtaining the multiple inputs without utilizing an indwelling catheter. In some embodiments, for example, obtaining the multiple inputs can include obtaining the multiple inputs via an external catheter, such as a condom catheter, a PureWick™ catheter, and/or one or more other non-indwelling catheters.

**[0095]** Obtaining the multiple inputs can include (i) receiving urine from the patient via the external catheter and (ii) obtaining an amount or quantity (e.g., a volume) of the received urine via, e.g., a weight sensor, an in-line flow sensor, a container fill level sensor, and/or one or more other urine measurement devices and/or techniques, including those described herein. In at least some embodiments, for example, obtaining the multiple inputs can include obtaining a first input of urine output volume data from the patient and obtaining a second input of urine output volume data from the patient at least some amount of time (e.g., at least 1 minute, 2 minutes, 5 minutes, 10 minutes, 15 minutes, 30 minutes, 60 minutes, and/or combinations thereof) after obtaining the first input. In some embodiments, third, fourth, fifth, sixth, etc. inputs of urine output volume data can be obtained in an at least generally similar manner to the first and second inputs. Additionally, or alternatively, obtaining the multiple inputs can include obtaining the multiple inputs via one or more sensors.

**[0096]** The one or more sensors used to obtain the urine output data can include an ultrasonic sensor, an MRI sensor, a radar sensor, a CT sensor, an EIT sensor, and/or one or

more other suitable sensors including one or more sensors described herein. The one or more sensors can be disposed externally on the patient and at least one of the one or more sensors can be configured to measure a dimension of or otherwise associated with an organ of the patient. For example, at least one of the one or more sensors can be positioned to measure a volume and/or a change in volume of a bladder of the patient, and/or a volume or a change in volume of fluid (e.g., urine) within the bladder.

**[0097]** In some embodiments, obtaining the urine output data (including, e.g., the multiple inputs of urine output volume data) can include obtaining the urine output data via user input. For example, a clinician or nurse can direct the patient the urinate into a container (e.g., a commode specimen collector or “witches hat”) and manually input urine output volume data. Additionally, or alternatively, the user can input urine output data to account for leaks, e.g., from an external or other non-indwelling catheter used by the patient. Obtaining the urine output data can include obtaining the urine output data over a time period (e.g., at least the prior 5 minutes, 15 minutes, 30 minutes, 60 minutes, 90 minutes, 120 minutes, 180 minutes, 240 minutes, and/or combinations thereof), in which individual inputs of urine output data are received no less than 10 minutes, 20 minutes, 30 minutes, 40 minutes, or 60 minutes apart from one another. In some embodiments, obtaining the urine output data can include prompting the patient to urinate, e.g., after a predetermined amount of time (e.g., up to 5 minutes, 15 minutes, 30 minutes, 60 minutes, 90 minutes, 120 minutes, 180 minutes, 240 minutes, and/or combinations thereof) has elapsed since the patient's prior urination. Obtaining individual inputs of the urine output data at the above-referenced spaced-apart intervals (i.e., in a non-continuous manner) is different from obtaining urine output rate data in a continuous manner via an indwelling catheter.

**[0098]** In some embodiments, block **312** can include determining an accumulated volume of urine output based at least partially on the obtained urine output data (e.g., the obtained multiple inputs of urine output data). The accumulated volume of urine output can refer to the sum of discrete individual inputs each obtained at different times. In this regard, the individual inputs are volumetric and/or do not correspond to a urine output rate. Moreover, in at least some embodiments, the accumulated volume does not include and/or is not based on inputs obtained on a continuous basis (e.g., inputs obtained less than once per minute) and/or using an indwelling catheter. Determining the accumulated volume of urine output can include adding individual inputs of the obtained urine output data together, determining the accumulated volume over a time period (e.g., at least the prior 5 minutes, 15 minutes, 30 minutes, 60 minutes, 90 minutes, 120 minutes, 180 minutes, 240 minutes, and/or combinations thereof), and/or determining an average or assumed urine output rate over the time period based on individual inputs of volumetric urine output data. To determine an average or assumed urine output rate over a time period, a urine output rate can be determined by considering the individual inputs of volumetric urine output data and the amount of time elapsed since the last input of volumetric urine output data obtained. For example, the urine output rate of 1000 mL/hr can be determined for an input of 500 mL received 30 minutes after the last input. The determined rate can be utilized by the system as an assumed steady rate over the given time period. In some embodiments, the multiple

inputs over the time period can be added together and divided by an amount of time (e.g., in hours) associated with the time period.

**[0099]** In some embodiments, block **312** can include (i) using an indwelling (e.g., Foley) catheter for at least one portion or phase of the fluid therapy and (ii) using a non-indwelling (e.g., condom) catheter for one or more other portions or phases of the fluid therapy. For example, in at least some embodiments the patient uses an indwelling catheter during the diuretic dose finding portion of the fluid therapy and, once the diuretic dose finding portion is completed, the patient can switch to using a non-indwelling catheter. While the patient makes use of the indwelling catheter, the fluid therapy provided to the patient can be based at least partially on urine received (e.g., excreted) from the patient via the indwelling catheter, including any urine output rate measurements based thereon. Once the patient switches to using a non-indwelling catheter, the fluid therapy provided to the patient can be based at least partially on urine received (e.g., urinated) from the patient via the non-indwelling catheter as described elsewhere herein.

**[0100]** At block **314**, the method **310** can include causing a diuretic to be provided to the patient at a diuretic dosage rate. Block **314** can be at least generally similar to block **204** of the method **200** (FIG. 2), but the diuretic dosage rate can be based on the obtained urine output volume data (block **312**) rather than a urine output rate. Additional details regarding causing the diuretic to be provided based urine output volume data are described elsewhere herein, including with reference to at least the method **400** of FIG. 4.

**[0101]** At block **316**, the method **310** can include causing a hydration fluid to be provided to the patient at a hydration rate. Block **316** can be at least generally similar to block **206** of the method **200** (FIG. 2), but the hydration rate can be based on the obtained urine output volume data (block **312**) rather than a urine output rate. Additional details regarding causing the hydration fluid to be provided based on urine output volume data are described elsewhere herein, including with reference to at least the method **500** of FIG. 5.

**[0102]** At block **318**, the method **310** can include adjusting at least one of the dosage rate of the diuretic or the hydration rate of the hydration fluid, thereby causing net fluid loss from the patient. Block **318** can be at least generally similar to block **208** of the method **200** (FIG. 2). For example, the dosage rate and/or the hydration rate can be associated with a diuretic dose finding portion, a hydration fluid replacement portion, a diuretic escalation portion, a therapy escalation portion, a therapy stopping portion, and/or a down titration portion of the patient's fluid therapy, and adjusting at least one of the dosage rate or the hydration rate can include adjusting the dosage rate and/or the hydration rate associated with one or more of the diuretic dose finding portion, the hydration fluid replacement portion, the diuretic escalation portion, the therapy escalation portion, the therapy stopping portion, and/or the down titration portion. Additional details regarding adjusting the dosage rate of the diuretic and/or the hydration rate of the hydration fluid are described elsewhere herein, including with reference to one or more of the methods **400-1000** of FIGS. 4-10.

**[0103]** In some embodiments, some or all of the blocks of the method **310** are performed as part of a medical procedure for treating the patient for a fluid overload condition. The method **310** can be used as a primary, standalone therapy for treating fluid overload, or can be used in combination with

other therapies (e.g., as a post-primary therapy to reduce the likelihood of re-hospitalization). The method **310** can be performed in any suitable setting, such as an inpatient setting or an outpatient setting. In embodiments where the method **310** is performed as an outpatient therapy, the overall duration of the method **310** can be reduced (e.g., to no more than 10 hours, 8 hours, 5 hours, 4 hours, 3 hours, 2 hours, or 1 hour). For example, during outpatient therapy, the method **300** can include causing an initial infusion or bolus of diuretic (e.g., 200 mg) to be administered to the patient, followed by a continuous infusion of diuretic at a rate (20 mg/hr) based on the initial infusion, such as described previously herein with reference to FIGS. 1 and 2. Diuretic administration can be stopped at some time (e.g., three hours) before the end (e.g., the scheduled end) of fluid therapy, and the response time of the patient (e.g., the amount and/or dosage rate of diuretic administered to the patient when the patient's urine output equals or is greater than a urine output threshold) can be used to determine an outpatient diuretic dosage for the patient.

**[0104]** One or more blocks **312-318** of the method **310** can be performed while the patient is awake and/or while the patient is sleeping. As set forth above, patients are generally not expected to urinate during sleep. Accordingly, to facilitate obtaining the multiple inputs while the patient is asleep, the method **310** can include waking the patient, or prompting a user to wake the patient, at least one during the night and instructing the patient to urinate. In other embodiments, one or more blocks **312-318** of the method **310** can be paused during night-time hours and/or when the patient is asleep. For example, a fluid therapy system, such as the system **100** (FIG. 1) can be placed in a "night mode" in which the fluid therapy system is configured to obtain multiple inputs of urine output volume data (block **312**) and/or determine an accumulated volume of urine output (block **312**), but does not adjust the fluid therapy (block **318**) unless or until the fluid therapy system is no longer in the night mode. In some embodiments, the fluid therapy system can reduce or halt diuretic administration while the patient is asleep. This can reduce the likelihood that the patient is roused from sleep by the urge to urinate and is expected to make the patient more comfortable during the night and/or better-rested the following morning. The fluid therapy system can initiate the reduction/halt in diuretic administration when the fluid therapy system is placed in night mode, during a time period associated with the patient's sleeping hours, in response to one or more inputs associated with the patient being asleep, and/or combinations thereof.

**[0105]** FIG. 4 is a block diagram illustrating a method **400** for diuretic dose finding for a patient, in accordance with embodiments of the present technology. At block **402**, the method **400** can include instructing the patient to void their bladder. Instructing the patient to void their bladder (and, e.g., the patient following said instruction) is expected to increase the accuracy of later-obtained urine output data, e.g., by expelling previously-accumulated urine from the patient's bladder such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block **402** is optional and can be omitted. In some embodiments, for example, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will, voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.



[0106] At block 404, the method 400 can include causing a diuretic to be administered to the patient at a diuretic dosage rate. The diuretic dosage rate can be an initial dosage rate, as described previously herein, including with reference to at least block 204 of the method 200 (FIG. 2).

[0107] At block 406, the method can include causing an increase to the diuretic dosage rate. Causing the increase can include causing the diuretic dosage rate to increase by a predetermined amount and/or over a predetermined time period, such as by “ramping” the diuretic dosage rate as described previously herein, including with reference to at least block 204 of the method 200 (FIG. 2). For example, after the diuretic has been administered at the initial diuretic dosage rate (block 404), the initial dosage rate can then be gradually increased (e.g., “ramped”), e.g., to elicit an increase in the patient’s urine output rate. The predetermined time period can be a duration of minutes or hours. For example, the predetermined time period can be up to 10 minutes, up to 20 minutes, up to 2 hours, up to 4 hours, or longer. For patients that elect not to use an indwelling catheter, it is expected to take longer to observe a response to the diuretic (e.g., increased urine output) compared to patients that elect to use an indwelling catheter. Accordingly, increasing the time period over which the diuretic dosage rate is increased is expected to provide more data regarding the patient’s urine output (e.g., by allowing more time for the patient to voluntarily urinate) which, in turn, is expected to increase the accuracy of the urine output data for the patient.

[0108] In some embodiments, causing the increase to the diuretic dosage rate can include causing the increase in multiple discrete steps and providing the diuretic at a continuous rate after one or more of the discrete steps. The patient can be instructed to void their bladder prior to the start of one or more of the discrete steps.

[0109] In some embodiments, causing the increase to the diuretic dosage rate can include causing a percentage of an administered dosage of the diuretic to be provided to the patient. The percentage can be associated with the continuous infusion phase, as described herein (e.g., with reference to block 414). For example, if 100 mg of a diuretic have been administered to the patient and the percentage is 20%, block 406 can include causing 20 mg/hr of diuretic to be administered to the patient, e.g., as or in addition to the increase to the diuretic dosage rate.

[0110] At block 408, the method 400 can include obtaining multiple inputs of urine output volume data from the patient. Block 408 can be at least generally similar to block 312 of the method 310 (FIG. 3B). For example, obtaining the multiple inputs can include obtaining the multiple inputs without using an indwelling catheter, such as via an external catheter, including a condom catheter or a PureWick™ catheter. In some embodiments, obtaining the multiple inputs can include obtaining the multiple inputs during the predetermined time period (block 406), e.g., while causing the increase to the diuretic dosage rate (block 406).

[0111] At block 410, the method 400 can include determining an accumulated volume of urine output data based on the obtained multiple inputs (block 408). Block 410 can be at least generally similar to block 312 of the method 310 (FIG. 3B).

[0112] At block 412, the method 400 can include determining whether the accumulated volume of urine output (block 410) exceeds (or is equal to) a urine output threshold

(e.g., at least 50 milliliters, 100 mL, 150 mL, 200 mL, 500 mL, and/or combinations thereof up to 1 liter (L), 1.5 L, or 2 L). In some embodiments, the urine output threshold can be a urine output rate, such as 525 mL/hr or another suitable urine output rate. Accordingly, determining whether the accumulated volume of urine output exceeds the urine output rate can include determining, based on the accumulated volume of urine output (block 410) and an amount of time that has elapsed, an estimated urine output rate of the patient. For example, if the patient has an accumulated volume of urine output of 1050 mL over a 2 hour time period, block 412 can include determining that the patient’s urine output rate over the 2 hour time period was 525 mL/hr, equal to the urine output threshold. If the accumulated volume of urine output exceeds (or is equal to) the urine output threshold (block 412, YES), the method 400 can include block 414. If not (block 412, NO), the method 400 can include block 416.

[0113] At block 414, the method 400 can include stopping the increase to the diuretic dosage rate and converting to continuous infusion, e.g., by causing the diuretic to be administered at a continuous dosage rate. Converting to continuous infusion can be at least generally similar to initiating the continuous delivery or fluid reduction phases described previously herein, including with reference to FIG. 2. For example, during continuous infusion, a continuous (e.g., non-increasing or non-ramping) dosage rate of diuretic can be administered to the patient to maintain the patient’s urine output rate at or above a desired output rate to cause net fluid loss. In some embodiments, the continuous dosage rate can be based, at least in part, on a value of the diuretic provided to the patient when the patient’s urine output exceeded (or equaled) the urine output threshold. For example, if the urine output threshold includes a volume of urine, then the continuous dosage rate can be equal to or a percentage of the diuretic dosage rate administered to the patient when the urine output equaled or exceeded the volume of urine. For example, if the patient has an accumulated volume of urine output of 1050 mL over a 2 hour time period, the continuous dosage rate can be equal to or a percentage of the diuretic dosage rate administered to the patient 2 hours ago. Similarly, if the urine output threshold includes a urine output rate threshold, then the continuous dosage rate can be equal to or a percentage of the diuretic dosage rate administered to the patient at an estimated time when the patient’s urine output rate equaled or exceeded the urine output rate threshold. For example, if the patient has a determined (e.g., average) output rate over a 2 hour time period of 525 mL/hr, the continuous dosage rate can be equal to or a percentage of the diuretic dosage rate administered to the patient 2 hours ago.

[0114] At block 416, the method 400 can include determining whether the accumulated volume of urine output (block 410) is greater than zero. If no (block 416, NO), the method 400 can include block 418. If yes (block 416, YES), the method 400 can include block 420.

[0115] At block 418, the method 400 can include setting the diuretic dosage rate to a default diuretic dosage rate. The default diuretic dosage rate can be up to 40 mg/hr, or one or more other suitable diuretic dosage rates, including other diuretic dosage rates described herein.

[0116] At block 420, the method 400 can include obtaining at least one additional input of urine output data. The at least one additional input of urine output data can be

obtained using any of the techniques described previously herein, including in a manner at least generally similar to block 408. After obtaining the at least one additional input of urine output data, the method 400 can return to block 410 and determine an accumulated volume of urine output data based on the obtained inputs of urine output data (blocks 408 and 420) and/or repeat one or more other blocks (e.g., blocks 412 and 416) of the method 400.

[0117] FIG. 5 is a block diagram illustrating a method 500 associated with providing hydration fluid to a patient, in accordance with embodiments of the present technology. At block 502, the method 500 can include obtaining multiple inputs of first urine output volume data from the patient over a first time period. Block 502 can be at least generally similar to block 312 of the method 300 (FIG. 3B). In some embodiments, if individual inputs of the multiple inputs include a volume greater than 1 L, the method 500 can include providing a prompt or recommendation to transition the patient to an indwelling catheter and/or to stop providing fluid therapy. Fluid therapy may be less effective for patients that are retaining large volumes of fluid (e.g., as indicated by urinations greater than 1 L). Transitioning these patients to an indwelling catheter can provide more data and/or more accurate data about these patients' urine output which, as a result, can improve their response to fluid therapy. If these patients refuse the indwelling catheter, stopping fluid therapy can reduce the likelihood of, or prevent entirely, side effects associated with patient overhydration.

[0118] At block 504, the method 500 can include causing a first amount of hydration fluid to be administered to the patient. The first amount can be equal to or less than a total urine output volume during the first time period (block 502), e.g., up to a hydration fluid threshold. In some embodiments, for example, causing the first amount of hydration fluid to be administered to the patient can include replacing a volume of urine output by the patient during a time period of 2 hours and/or up to a hydration fluid threshold of 250 mL. In other embodiments, the time period can be up to 10 minutes, 20 minutes, 30 minutes, 1 hour, 1.5 hours, 2 hours, 2.5 hours, 5 hours, and/or combinations thereof, and/or the hydration fluid threshold can be at least 25 mL, 50 mL, 100 mL, 200 mL, 250 mL, 500 mL, e.g., up to 1 L, 1.5 L, 2 L, 3 L, and/or combinations thereof. Additionally, or alternatively, causing the first amount of hydration fluid to be administered to the patient can include causing an amount of hydration fluid equaling a urine output volume of a first input of the multiple inputs (block 502) to be administered to the patient. This amount can correspond to the patient's initial bladder void and subsequent voids by the patient can be used for administering the hydration fluid during the first time period, e.g., up to a hydration fluid threshold.

[0119] At block 506, the method 500 can include obtaining multiple inputs of second urine output data over a second time period. Block 506 can be at least generally similar to block 312 of the method 300 (FIG. 3B) and/or block 502. Obtaining the multiple inputs of second urine output data can include obtaining the multiple inputs during and/or after causing the first amount of hydration fluid to be administered to the patient (block 504). However, in at least some embodiments, blocks 502 and/or 504 can be omitted and the second time period can be an initial time period and/or the multiple inputs of second urine output data can be initial urine output data for the patient. In some embodiments, obtaining the multiple inputs can include estimating a urine

rate of the patient based on the obtained multiple inputs. For example, each of the multiple inputs can correspond to the patient voiding their bladder, and the volume of urine received from the patient during multiple voids and the amount of time between individual voids can be used to determine an average urine rate of the patient.

[0120] At block 508, the method 500 can include obtaining a urine replacement ratio over the second time period (block 506). The urine replacement ratio can correspond to an amount or average rate of urine excreted by the patient during the second time period, and/or can be a percentage of the second urine output volume data. In one specific example, if the patient's second urine output volume data over the second time period (e.g., the past hour) amounts to an average urine rate of 425 mL/hr, the urine replacement ratio can be 47%, e.g., so that an amount of hydration fluid equal to about 47% of the patient's urine output over the time period (i.e., about 200 mL/hr over the next hour) is infused into the patient. Generally, as the patient's urine output (e.g., urine output rate) increases, the hydration rate can increase as well, but at a rate less than that of the urine output rate, e.g., to decrease the patient's net fluid balance (e.g., so that the net fluid balance becomes more negative) and/or increase the patient's net fluid loss. Accordingly, the urine replacement ratio can vary based on the second urine output volume data (block 506), e.g., to produce a desired net fluid loss from the patient.

[0121] At block 510, the method 500 can include causing a second amount of hydration fluid to be administered to the patient. The second amount can be based, at least in part, on the urine replacement ratio. For example, the second amount of hydration fluid can be a percentage (e.g., corresponding to the urine replacement ratio in block 508) of an amount of urine excreted by the patient over the time second period and can be infused into the patient at a rate that is equal to, or substantially equal to, the rate at which the patient excreted that urine. In other embodiments, the amount of hydration fluid infused into the patient can equal, or substantially equal, the amount of urine the patient excreted during the second time period, but the hydration fluid can be administered at a high rate (e.g., a maximum allowable infusion rate, such as up to 500 mL/hr) over a time period less than the second time period. The hydration fluid can be administered at this high rate until the amount administered is equal to, or is substantially equal to, the amount of urine the patient excreted during the second time period. For example, if the patient excreted 425 mL of urine over the past hour, the system would determine that the patient should receive 200 mL of hydration fluid, and causing the second amount of hydration fluid to be administered to the patient can include causing the hydration fluid to be administered at a rate of 500 mL/hr for 24 minutes, resulting in 200 mL of hydration fluid being administered to the patient. In at least some embodiments, the second amount of hydration fluid is infused only in response to measured or obtained urine output during the second time period.

[0122] In some embodiments, the amount of hydration fluid infused into the patient can decrease as the patient's urine output increases. For example, if the patient's urine output is below a first threshold (e.g., 175 mL/hr, 225 mL/hr, 275 mL/hr, or within a range of 175-275 mL/hr), the amount of hydration fluid administered to the patient may be zero, or a minimum amount (e.g., 10 mL/hr), e.g., to keep the vein pressurized and open (referred to as a Keep Vein Open

(KVO) rate). While the urine output is below the first threshold, rehydration is less or not necessary and, because a general goal of fluid therapy is to maximize net fluid removal, no infusion of hydration fluid may be provided when the urine output is below the first threshold. As previously described, in some embodiments, the hydration fluid rate may match the urine output for a first period of time or until a minimum amount of hydration fluid is infused.

**[0123]** If the patient's urine output is between the first threshold and a second threshold (e.g., 225, 375 ml/hr, 425 ml/hr, 500 ml/hr, or within a range of 225-500 ml/hr), substantially all (e.g., at least 90% or 100%) of the urine volume (i.e., between the first and second thresholds) can be replaced by hydration fluid, e.g., to ensure the kidneys are getting enough fluid and salt, and/or to inhibit a hypotensive state (e.g., if the lower range is 225 ml/hr, and the urine rate is 325 ml/hr, 100 ml of saline will be infused).

**[0124]** If the patient's urine output is between the second threshold and a third threshold (e.g., 975 ml/hr, 1025 ml/hr, 1100 ml/hr, or within a range of 975-1100 ml/hr), substantially all (e.g., at least 90% or 100%) of the urine volume between the first and second thresholds can be replaced by hydration fluid, and 40%, 45%, 50%, or a range of 40-50% of the urine volume above the second threshold is replaced. By replacing only a portion of the urine output above the second threshold, net fluid balance as well as net sodium balance can be decreased. Urine typically has less sodium concentration than blood or normal saline, which is approximately 154 mmol/L. As such, replacing urine with an equal amount of hydration fluid may result in increased and undesirable sodium levels. In some embodiments, providing saline or hydration fluid at a rate of more than 50% of the urine output can increase the risk of giving them more sodium than they are releasing. Accordingly, limiting the hydration fluid rate to 50% can protect patients having low sodium urine, while also enabling patients having higher sodium urine to experience faster net fluid and sodium removal. Urine output above the second threshold can serve as an indication that the kidneys are functioning well and not in a hypotensive state, and so the reduced hydration fluid rate is more acceptable.

**[0125]** If the patient's urine output is above the third threshold, substantially all (e.g., at least 90% or 100%) of the urine volume between the first and second thresholds can be replaced by hydration fluid, 40%, 45%, 50%, or a range of 40-50% of the urine volume between the second and third thresholds can be replaced, and none of the urine volume in the fourth region (IV) above the third threshold is replaced. In doing so, the net fluid balance can be further decreased.

**[0126]** FIG. 6A is a block diagram illustrating a method **600** associated with increasing a patient's diuretic dosage, in accordance with embodiments of the present technology. At block **602**, the method **600** can include instructing the patient to void their bladder. By voiding their bladder, the patient can expel urine accumulated within the bladder which is expected to increase the accuracy of later-obtained urine output data, e.g., by removing previously-accumulated urine such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block **602** is optional and can be omitted. In some embodiments, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will,

voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.

**[0127]** At block **604**, the method **600** can include obtaining a urine output of the patient over a predetermined previous time period. Obtaining the urine output can include obtaining multiple inputs of urine output volume data, as described previously herein, e.g., with reference to block **312** of the method **310** (FIG. 3B). The predetermined previous time period can be up to 10 minutes, 20 minutes, 30 minutes, 1 hour, 1.5 hours, 2 hours, 2.5 hours, 5 hours, and/or combinations thereof.

**[0128]** At block **606**, the method **600** can include determining whether the obtained urine output over the predetermined previous time period (block **604**) is less than a predetermined urine output threshold. In some embodiments, determining whether the obtained urine output is less than the predetermined urine output threshold includes determining whether an obtained urine output volume is less than a predetermined urine output volume threshold. For example, the predetermined urine output threshold can include a volume of at least 300 milliliters (mL), 400 mL, 500 mL, and/or combinations thereof up to 975 mL, 1 liter (L), 1.3 L, 1.5 L, 2 L, or another suitable volume. In some embodiments, the predetermined urine output threshold includes a volume associated with a target urine rate over the predetermined previous time period. For example, the target urine rate can be 325 mL/hr and, if the predetermined previous time period is 3 hours, the predetermined urine output threshold can be 975 mL, i.e., the volume of urine output by a patient with a urine rate of 325 mL/hr over a three hour time period. In other embodiments, the target urine rate can be up to 200 mL/hr, 300 mL/hr, 400 mL/hr, 500 mL/hr, or another suitable target urine rate. If the urine output over the predetermined previous time period is less than the predetermined urine output threshold (block **606**, YES), the method **600** can include block **608**. If not (block **606**, NO), the method **600** can return to block **604** and/or repeat block **604** and/or block **606**.

**[0129]** At block **608**, the method **600** can include recommending an increase to a dosage rate of a diuretic administered to the patient. In some embodiments, recommending the increase to the diuretic dosage rate can include ramping or re-ramping the diuretic dosage, as described previously herein with reference to at least the method **200** (FIG. 2). In some embodiments, the recommendation can cause a fluid therapy system, such as the system **100** (FIG. 1) to automatically increase the diuretic dosage rate. In these and/or other embodiments, recommending the increase to the diuretic dosage rate can include prompting a user (e.g., a clinician, a nurse, a practitioner, etc.) to increase the diuretic dosage rate. In some embodiments, recommending the increase to the diuretic dosage rate can include a recommendation or instruction that the patient should void their bladder prior to initiating the increase to the diuretic dosage rate. The volume of urine output during the void can be used to confirm that determination in block **606**, e.g., that the patient's urine output is less than the predetermined threshold.

**[0130]** FIG. 6B is a block diagram illustrating a method **610** associated with increasing a patient's diuretic dosage, in accordance with embodiments of the present technology. At block **612**, the method **610** can include instructing the patient to void their bladder. By voiding their bladder, the

patient can expel urine accumulated within the bladder which is expected to increase the accuracy of later-obtained urine output data, e.g., by removing previously-accumulated urine such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block **612** is optional and can be omitted. In some embodiments, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will, voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.

[0131] At block **614**, the method **610** can include receiving confirmation that the patient has voided their bladder. Receiving confirming that the patient has voided their bladder can include prompting a user to measure a volume of the patient's bladder and/or a volume of fluid within the patient's bladder, e.g., to confirm that the patient has in fact voided their bladder. The volume of the patient's bladder can be measured using ultrasound, a CT scan, an MRI scan, and/or one or more other volume measurement methodologies. Receiving the confirmation can confirm that the patient's bladder is, e.g., empty, which as noted above is expected to increase the accuracy of subsequent urine output data. Block **614** is optional and can be omitted.

[0132] At block **616**, the method **610** can include causing a diuretic to be administered to the patient. In some embodiments, causing the diuretic to be administered can include causing the diuretic to be administered at an increasing or ramping diuretic dosage rate, as described previously herein, at least with reference to block **204** of the method **200** (FIG. 2).

[0133] At block **618**, the method **610** can include obtaining an estimated amount of fluid in the patient's bladder. Obtaining the estimated amount of fluid can include obtaining the estimated amount of fluid via one or more sensors. For example, one or more sensors can be disposed external to the patient's bladder and used to determine a volume or a change in volume of the bladder, and/or a volume of urine and/or a change in volume of urine within the bladder. The sensors can include one or more of the sensors described previously herein, such as an ultrasound sensor, a CT sensor, an MRI sensor, and/or one or more other suitable sensors. In some embodiments, obtaining the estimated amount of fluid can include receiving an estimated amount of fluid provided by a clinician or other user.

[0134] At block **620**, the method **610** can include determining whether the estimated amount of fluid in the bladder is less than a fluid amount threshold. The fluid amount threshold can be at least 100 mL, 150 mL, 200 mL, 250 mL, 300 mL, and/or combinations thereof up to 600 mL, or another volume of fluid associated with the patient's bladder being full or substantially full. If the estimated amount of fluid is less than the fluid amount threshold (block **620**, YES), the method **610** can return to block **616** and/or continue causing diuretic to be administered the patient. If not (block **620**, NO), the method **610** can include block **622**.

[0135] At block **622**, the method **610** can include administering the diuretic at a continuous diuretic dosage rate. Administering the diuretic at the continuous diuretic dosage rate can be at least generally similar to administering the diuretic during the continuous delivery phase or fluid reduction phase described previously herein.

[0136] FIG. 6C is a block diagram illustrating a method **630** associated with increasing a patient's diuretic dosage, in

accordance with embodiments of the present technology. At block **632**, the method **630** can include instructing the patient to void their bladder. By voiding their bladder, the patient can expel urine accumulated within the bladder which is expected to increase the accuracy of later-obtained urine output data, e.g., by removing previously-accumulated urine such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block **632** is optional and can be omitted. In some embodiments, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will, voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.

[0137] At block **634**, the method **630** can include receiving confirmation that the patient has voided their bladder. Receiving confirming that the patient has voided their bladder can include prompting a user to measure a volume of the patient's bladder and/or a volume of fluid within the patient's bladder, e.g., to confirm that the patient has in fact voided their bladder. Receiving the confirmation can confirm that the patient's bladder is, e.g., empty, which as noted above is expected to increase the accuracy of subsequent urine output data. Block **634** is optional and can be omitted.

[0138] At block **636**, the method **630** can include causing a diuretic to be administered to the patient. In some embodiments, causing the diuretic to be administered to the patient can include causing a bolus dose of diuretic to be administered to the patient, such as a bolus dose of up to 50 mg, 100 mg, 150 mg, 200 mg, 250 mg, or another suitable diuretic dosage. In these and/or other embodiments, block **636** can be at least generally similar to block **204** of the method **200** (FIG. 2). For example, in some embodiments causing the diuretic to be administered can include causing the diuretic to be administered at an increasing or ramping diuretic dosage rate, e.g., before, during, after, and/or instead of administering one or more bolus doses.

[0139] At block **638**, the method **630** can include waiting a predetermined amount of time. The predetermined amount of time can be at least 10 minutes, at least 20 minutes, at least 30 minutes, at least 1 hour, at least 2 hours, and/or combinations thereof, up to 5 hours, 6 hours, 7 hours, 8 hours, or 12 hours. In some embodiments, waiting the predetermined amount of time can include instructing the patient to avoid urinating for at least the predetermined amount of time. Block **638** is optional and can be omitted.

[0140] At block **640**, the method **630** can include obtaining a urine output of the patient. Obtaining the urine output can include instructing the patient to void their bladder after the predetermined amount of time (block **638**) and measuring a volume of urine received from the patient. Additionally, or alternatively, obtaining the urine output can include waiting for the patient to voluntarily urinate and/or obtaining an amount of time between the predetermined amount of time (block **638**) and the patient's voluntary urination. The amount of time between the predetermined amount of time (block **638**) and the patient's voluntary urination can be used to determine an average urine output rate since the patient's prior urination (e.g., blocks **632** and **634**). The urine output can include a urine output rate obtained via one or more sensors configured to measure a volume or a change in volume of the patient's bladder, as described elsewhere herein.

[0141] At block 642, the method 630 can include adjusting the administration of the diuretic based, at least in part, on the urine output of the patient. In some embodiments, adjusting the administration of the diuretic includes transitioning from a ramped diuretic delivery to a continuous diuretic dosage. The continuous diuretic dosage can be determined based, at least in part, on the obtained urine output, as described elsewhere herein.

[0142] FIG. 6D is a block diagram illustrating a method 650 associated with increasing a patient's diuretic dosage, in accordance with embodiments of the present technology. At block 652, the method 650 can include causing a first amount of diuretic to be administered to a patient. The first amount can be a bolus dose of, for example, up to 50 mg, 100 mg, 150 mg, 200 mg, and/or combinations thereof. In some embodiments, the first amount can be administered over a first time period, such as up to 10 minutes, 20 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, and/or combinations thereof.

[0143] At block 654, the method 650 can include causing a second amount of diuretic to be administered to the patient. The second amount can be administered to the patient after administering (e.g., completing the administration of) the first amount of the diuretic (block 652). In some embodiments, the second amount can be a predetermined amount, e.g., not based on the patient's urine output. For example, in at least some embodiments the second amount can be a continuous diuretic dosage rate of 40 mg/hr, a bolus dose, or another suitable diuretic dosage. The diuretic associated with block 654 can be the same as or different than the diuretic associated with block 652.

[0144] At block 656, the method 650 can include determining whether the patient has voided their bladder. Determining whether the patient has voided their bladder can include, for example, receiving urine output data via one or more sensors indicating that the patient has or is currently voiding their bladder. If the patient has voided their bladder (block 656, YES), the method 650 can include block 658. If not (block 656, NO), the method can return to block 654 and/or continue to cause the second amount of diuretic to be administered to the patient.

[0145] At block 658, the method 650 can include obtaining at least one input of urine output data from the patient. Block 658 can be at least generally similar to block 312 of the method 300 (FIG. 3B).

[0146] At block 660, the method can include causing an amount of a hydration fluid to be administered to the patient. The amount can be based, at least in part, on the obtained urine output data (block 658). For example, the urine output data can include a volume of urine and the amount of the hydration fluid can equal, or be some percentage (e.g., up to 50%, 60%, 70%, 80%, 90%, 95%, and/or combinations thereof) of, the volume of urine. The amount of the hydration fluid can be administered continuously or intermittently (e.g., as one or more bolus doses). In some embodiments, the amount administered can be less than the amount that would be administered to the patient if the patient were using an indwelling (e.g., Foley) catheter.

[0147] FIG. 6E is a block diagram illustrating a method 601 associated with increasing a patient's diuretic dosage, in accordance with embodiments of the present technology. At block 603, the method 601 can include instructing the patient to void their bladder. By voiding their bladder, the patient can expel urine accumulated within the bladder

which is expected to increase the accuracy of later-obtained urine output data, e.g., by removing previously-accumulated urine such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block 603 is optional and can be omitted. In some embodiments, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will, voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.

[0148] At block 605, the method 601 can include receiving confirmation that the patient has voided their bladder. Receiving confirming that the patient has voided their bladder can include prompting a user to measure a volume of the patient's bladder and/or a volume of fluid within the patient's bladder, e.g., to confirm that the patient has in fact voided their bladder. Receiving the confirmation can confirm that the patient's bladder is, e.g., empty, which as noted above is expected to increase the accuracy of subsequent urine output data. Block 605 is optional and can be omitted.

[0149] At block 607, the method 601 can include causing an amount of a diuretic to be administered to the patient. Causing the amount of the diuretic to be administered can include causing a bolus dose of the diuretic to be administered to the patient. The bolus dose can be, for example, up to 5 mg, 10 mg, 15 mg, 20 mg, 25 mg, 30 mg, 35 mg, 40 mg, 50 mg, 100 mg, 150 mg, 200 mg, and/or combinations thereof. Causing the amount of the diuretic to be administered can include causing the amount of the diuretic to be administered over a predetermined time period, such as up to 1 second, 5 seconds, 10 seconds, 15 seconds, 30 seconds, 1 minute, 5 minutes, 15 minutes, 30 minutes, 1 hour, and/or combinations thereof.

[0150] At block 609, the method 601 can include causing a diuretic (e.g., the same or different diuretic than in block 607) to be administered to the patient at a first diuretic dosage rate. The diuretic dosage rate can be based, at least in part, on the administered amount of diuretic (block 607). For example, the diuretic dosage rate can be based on a percentage of the administered amount of diuretic (block 607), such as a rate that administers up to 5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, or 100% of the administered amount of diuretic over a predetermined time period (e.g., up to 1 hour, 2 hours, 4 hours, and/or combinations thereof). In one particular example, if the administered amount of diuretic (block 607) was 20 mg, the diuretic dosage rate can be 5 mg/hr, 10 mg/hr, 15 mg/hr, 20 mg/hr, 30 mg/hr, or 40 mg/hr. In at least some embodiments, the diuretic dosage rate can be a continuous diuretic dosage rate, e.g., associated with the continuous delivery phase or fluid reduction phase described previously herein.

[0151] At block 611, the method 601 can include waiting (or prompting a user to wait) a predetermined amount of time. The predetermined amount of time can be up to 5 minutes, 10 minutes, 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, and/or combinations thereof. In some embodiment, block 611 can be at least generally similar to block 638 of the method 630 (FIG. 6C). Block 611 is optional and can be omitted.

[0152] At block 613, the method 601 can include obtaining a total urine production of the patient. Obtaining the total urine production can include obtaining the total urine production after the predetermined amount of time (block 611). Block 613 can be at least generally similar to block 618 of

the method **610** (FIG. 6B) and can include, e.g., obtaining the estimated amount of fluid via one or more sensors. For example, one or more sensors can be disposed external to the patient's bladder and used to determine a volume or a change in volume of the bladder, and/or a volume of urine and/or a change in volume of urine within the bladder. The sensors can include one or more of the sensors described previously herein, such as an ultrasound sensor, a CT sensor, an MRI sensor, and/or one or more other suitable sensors. Additionally, or alternatively, obtaining the total urine production can include measuring a volume of urine collected in the collection container **112** (FIG. 1) and/or otherwise removed from the patient, such as described previously herein, at least with reference to block **312** of the method **310** (FIG. 3B).

[0153] At block **615**, the method **601** can include determining whether the total urine production (block **613**) is less than a urine production threshold. The urine production threshold can be a urine volume of up to 50 mL, 100 mL, 150 mL, 200 mL, 250 mL, 300 mL, 400 mL, 500 mL, 600 mL, or another volume of fluid associated with the patient's bladder being full or substantially full. If the total urine production is less than the urine production threshold (block **615**, YES), the method **601** can include block **619**. If not (block **615**, NO), the method can include block **617**.

[0154] At block **617**, the method **601** can include continuing to cause the diuretic to be administered at the diuretic dosage rate (block **609**). In some embodiments, continuing to cause the diuretic to be administered at the diuretic dosage rate is at least generally similar to transitioning to the continuous delivery phase or fluid reduction phase described previously herein.

[0155] At block **619**, the method **601** can include causing an increase to the amount of the diuretic administered to the patient. In some embodiments, causing the increase can include causing another bolus dose of diuretic to be administered to the patient. This second bolus dose can be at least generally similar to the initial bolus dose (block **607**), or some percentage (e.g., up to 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 200%, and/or combinations thereof) greater or less than one or more previous bolus doses. Additionally, or alternatively, causing the increase can include causing an increase to the diuretic dosage rate (block **609**), for example, by ramping the diuretic dosage rate as described previously herein.

[0156] At block **621**, the method **601** can include determining whether the increased amount of diuretic is greater than a diuretic threshold. The diuretic threshold can be a maximum diuretic bolus dose, such as a bolus dose of up to 50 mg, 100 mg, 150 mg, 200 mg, 250 mg, 300 mg, 350 mg, 400 mg, and/or combinations thereof. If the increased amount of diuretic is greater than the diuretic threshold (block **621**, YES), the method **601** can include block **623**. If not (block **621**, NO), the method **601** can continue causing the diuretic to be administered to the patient, e.g., at the increased diuretic dosage rate (block **619**) and return to block **611**.

[0157] At block **623**, the method **601** can include causing the diuretic to be administered to the patient at a second diuretic dosage rate. The second diuretic dosage rate can be based, at least in part, on the threshold amount of diuretic (block **621**). For example, the second diuretic dosage rate can be associated with the continuous delivery phase or fluid reduction phase described previously herein and can be based

on a percentage of the threshold amount of diuretic, e.g., a percentage of the maximum diuretic bolus dose.

[0158] In some embodiments, the method **601** can include causing hydration fluid to be delivered to the patient, e.g., during one or more of the blocks **603-623**. Causing the hydration fluid to be delivered to the patient can include causing hydration fluid to be delivered after detecting urine output (e.g., an increase in urine within the collection container **112**) from the patient. The hydration fluid can be administered at a hydration fluid rate configured to allow constant hydration fluid infusion between the patient's bladder voids. In some embodiments, causing the hydration fluid to be delivered to the patient includes causing the hydration fluid to be administered based, at least in part, on a urine replacement ratio as described previously with reference to FIG. 5.

[0159] FIG. 7 is a block diagram illustrating a method **700** associated with escalating a patient's fluid therapy, in accordance with embodiments of the present technology. At block **702**, the method can include instructing the patient to void their bladder. By voiding their bladder, the patient can expel urine accumulated within the bladder which is expected to increase the accuracy of later-obtained urine output data, e.g., by removing previously-accumulated urine such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block **702** is optional and can be omitted. In some embodiments, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will, voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.

[0160] At block **704**, the method **700** can include obtaining (i) multiple inputs of urine output volume data from a patient over a time period, (ii) a dosage rate of a diuretic administered to the patient, (iii) an amount of net fluid removed from the patient, and/or (iv) an amount of estimated excess volume to be removed from the patient. Obtaining the multiple inputs can be at least generally similar to block **312** of the method **310** (FIG. 3B). The predetermined time period can be a duration of minutes or hours, such as up to 10 minutes, up to 20 minutes, up to 30 minutes, up to 1 hour, up to 2 hours, up to 4 hours, or longer. The dosage rate can be a continuous dosage rate, e.g., associated with the continuous delivery phase or fluid reduction phase described previously herein. The amount of net fluid removed from the patient can be based, at least in part, on the multiple inputs and an amount of hydration fluid delivered to the patient. The amount of estimated excess volume to be removed from the patient can be based, at least in part, on the amount of net fluid removed and/or a target fluid removal volume for the patient.

[0161] At block **706**, the method **700** can include determining whether (i) the urine output volume data over the time period is less than a urine output threshold, (ii) the dosage rate of the diuretic is less than a dosage rate threshold, (iii) the amount of net fluid removed is less than a percent estimated excess volume threshold, and/or (iv) the amount of estimated excess volume to be removed is greater than an excess fluid threshold. The urine output threshold can include a volume of urine, such as at least 300 mL, 400 mL, 500 mL, and/or combinations thereof up to 975 mL, 1 L, 1.3 L, 1.5 L, 2 L, or another suitable volume. The dosage rate threshold can be up to 10 mg/hr, 20 mg/hr, 30 mg/hr, 40 mg/hr, 50 mg/hr, and/or combinations thereof. The percent

estimated excess volume threshold can be based, at least in part, on the amount of net fluid removed and a target fluid removal volume for the patient, e.g., the proportion of the target fluid removal volume that the amount of net fluid removed represents. The excess fluid threshold can be an amount of fluid still expected to be removed from the patient, such as up to 500 mL, 1 L, 1.5 L, and/or combinations thereof. If all or a subset of (i)-(iv) are true (block 706, YES), the method 700 can include block 708. If all of (i)-(iv) are not true (block 706, NO), the method 700 can return to block 704 and/or repeat one or more other blocks of the method 700.

[0162] At block 708, the method 700 can include recommending an increase to the dosage rate of the diuretic and/or to an infusion rate of a hydration fluid administered to the patient. Block 708 can be at least generally similar to block 208 of the method 200 (FIG. 2) and/or block 608 of the method 600 (FIG. 6A). In some embodiments, recommending the increase to the diuretic dosage rate can include ramping or re-ramping the diuretic dosage, as described previously herein with reference to at least the method 200 (FIG. 2). In some embodiments, recommending the increase to the hydration fluid infusion rate can include increasing a matching percentage associated with the hydration fluid infusion rate. In some embodiments, the recommendation can cause a fluid therapy system, such as the system 100 (FIG. 1) to automatically increase or otherwise adjust the diuretic dosage rate and/or the hydration fluid infusion rate. In these and/or other embodiments, recommending the increase can include prompting a user (e.g., a clinician, a nurse, a practitioner, etc.) to increase the diuretic dosage rate and/or the hydration fluid infusion rate. In some embodiments, recommending the increase can include a recommendation or instruction that the patient should void their bladder prior to initiating the increase. The volume of urine output during the void can be used to confirm the determination in block 706.

[0163] FIG. 8 is a block diagram illustrating a method 800 associated with stopping a patient's fluid therapy, in accordance with embodiments of the present technology. At block 802, the method 800 can include instructing the patient to void their bladder. By voiding their bladder, the patient can expel urine accumulated within the bladder which is expected to increase the accuracy of later-obtained urine output data, e.g., by removing previously-accumulated urine such that the later-obtained urine output data reflects urine output after the start of fluid therapy. However, block 802 is optional and can be omitted. In some embodiments, rather than instructing the patient to void their bladder, the patient can be instructed to urinate normally (e.g., at will, voluntarily, in response to an urge to do so, etc.) and/or no instruction regarding urination can be provided to the patient.

[0164] At block 804, the method 800 can include obtaining (i) multiple inputs of urine output volume data from a patient over a time period, (ii) a dosage rate of a diuretic administered to the patient, (iii) an amount of net fluid removed from the patient, and/or (iv) an amount of estimated excess volume to be removed from the patient. Block 804 can be at least generally similar to block 704 of the method (FIG. 7).

[0165] At block 806, the method 800 can include determining whether (i) the urine output volume data over the time period is less than a urine output threshold, (ii) the

dosage rate of the diuretic is greater than a dosage rate threshold, (iii) the amount of net fluid removed is greater than a percent estimated excess volume threshold, and/or (iv) the amount of estimated excess volume to be removed is less than an excess fluid threshold. The urine output threshold, the dosage rate threshold, The percent estimated excess volume threshold and/or the excess fluid threshold can be at least generally similar to the correspondingly-named thresholds described previously with reference to block 706 of the method 700 (FIG. 7). If all or a subset of (i)-(iv) are true (block 806, YES), the method 800 can include block 808. If all of (i)-(iv) are not true (block 806, NO), the method 800 can return to block 804 and/or repeat one or more other blocks of the method 800.

[0166] At block 808, the method 800 can include recommending stopping the patient's fluid therapy. In some embodiments, the recommendation can cause a fluid therapy system, such as the system 100 (FIG. 1) to automatically stop the patient's fluid therapy. In these and/or other embodiments, recommending to stop the patient's fluid therapy can include prompting a user (e.g., a clinician, a nurse, a practitioner, etc.) to stop the patient's fluid therapy. If the user does not respond to the prompt within a predetermined amount of time (e.g., up to 10 minutes, 20 minutes, 30 minutes, 1 hour, 2 hours, and/or combinations thereof), block 808 can include automatically causing the fluid therapy system to stop the patient's fluid therapy.

[0167] FIG. 9 illustrates a method 900 associated with down-titrating a patient's fluid therapy, in accordance with embodiments of the present technology. At block 902, the method 900 can include obtaining multiple inputs of urine output volume data from the patient. Block 902 can be at least generally similar to block 312 of the method 310 (FIG. 3B).

[0168] At block 904, the method 900 can include determining an accumulated volume of urine output over a time period based on the multiple inputs (block 902). Block 904 can be at least generally similar to block 314 of the method 310 (FIG. 3B). The time period can be up to 1 hr, 2 hrs, 3 hrs, 4 hrs, and/or combinations thereof.

[0169] At block 906, the method 900 can include determining whether the accumulated volume of urine output over the time period (block 904) is greater than a urine output threshold. The urine output threshold can include a volume of urine (e.g., up to 100 mL, 200 mL, 300 mL, 325 mL, 500 mL, 650 mL, 975 mL, 1 L, 1.3 L, 1.5 L, 2 L, and/or combinations thereof). If the accumulated volume of urine output over the time period is greater than the urine output threshold (block 906, YES), the method 900 can include block 910. If not (block 906, NO), the method can include block 908.

[0170] At block 908, the method 900 can include obtaining at least one additional input of urine output volume data. Block 908 can be at least generally similar to block 902. After obtaining the at least one additional input of urine output volume data, the method 900 can include determining an accumulated volume of urine output based on the obtained inputs (e.g., the multiple inputs in block 902 and the at least one additional input in block 908) and/or repeating one or more other blocks of the method 900.

[0171] At block 910, the method 900 can include reducing a diuretic infusion rate by a predetermined amount. The predetermined amount can be a percentage of the current

diuretic infusion rate, such as up to 10%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 75%, 80%, 90%, or 100% of the current diuretic infusion rate.

[0172] FIG. 10 is a block diagram illustrated a method 1000 of providing outputs associated with a patient's fluid therapy based at least partially on a urine output (e.g., a urine output rate) and a urine sodium level of the patient, in accordance with embodiments of the present technology. The method 1000 is illustrated as a series of steps, acts, processes, process portions, and/or blocks 1002-1006. At least some of the blocks 1002-1006 can be performed by a fluid management system and/or one or more components thereof, such as the system 100 and/or the controller 140 of FIG. 1.

[0173] At block 1002, the method 1000 includes obtaining multiple inputs of urine output volume data from the patient. Block 1002 can be at least generally similar or identical to block 312 (FIG. 3B).

[0174] At block 1004, the method 1000 includes obtaining a urine sodium level (e.g., concentration) of the patient. The sodium concentration of excreted urine is an important measure of health of a heart failure patient undergoing fluid therapy. For example, one of the functions of the kidney is to vary the sodium content of excreted urine in order to maintain serum sodium at a consistent level. One of the drivers of worsening heart failure is the derangement of the patient's native sodium regulation mechanisms. When urine sodium concentration drops below a certain level (e.g., 75 millimoles per liter ("mmol/L")), this may indicate that the kidneys are retaining sodium to maintain serum sodium levels. If urine sodium concentration rises above a certain level (e.g., 100 mmol/L), this may indicate that the kidneys are excreting excess sodium to maintain appropriate serum sodium levels. The urine sodium level can be determined in a number of ways, including by the user entering in the value of a lab-measured urine sodium concentration and/or based on a sensor that measures the patient's urine sodium concentration (i.e., ion selective electrode, conductivity sensor) and/or one or more characteristics of the patient's urine that are associated with the patient's urine sodium level. In at least some embodiments, for example, obtaining the urine sodium level of the patient can include obtaining the urine sodium level based at least partially on a conductivity of one or more of the multiple inputs of urine output obtained from the patient. Urine conductivity is highly correlated with urine sodium levels and is thus a good surrogate for urine sodium. Additionally, measuring urine conductivity is generally less expensive and easier than measuring sodium directly and can provide a signal that is, e.g., more robust and/or less noisy.

[0175] During fluid therapy, sodium containing fluid (e.g., hydration fluid, such as 0.9% saline) can be infused to the patient based at least partially on the patient's urine output. If it is determined (e.g., via the controller 140; FIG. 1) that the patient's urine sodium concentration is dropping and the patient is receiving normal amounts of hydration fluid, there is a potential risk that continued hydration fluid administration could push the patient into a serum sodium positive state. Thus, if the patient's urine sodium drops, the fluid therapy system (e.g., the controller 140) may suggest modifications to the therapy to maintain safety and/or prevent harm to the patient. If, on the other hand, the patient's urine sodium concentration is high, the fluid therapy system may not make or suggest any modifications to the patient's fluid

therapy, as a high urine sodium concentration indicates that the patient's kidneys are tolerating therapy well. In some embodiments, the hydration fluid infusion rate may be reduced based at least partially on the patient's urine sodium level in order to maximize the net fluid and/or net sodium removed from the patient.

[0176] In some embodiments, obtaining the urine conductivity includes measuring the urine conductivity using one or more conductivity sensors. The urine conductivity can be measured continuously or intermittently via the one or more conductivity sensors. The measured urine conductivity can be used to provide a corresponding urine sodium concentration. For example, the controller 140 (FIG. 1) can estimate or determine the patient's urine sodium concentration based at least in part on the urine conductivity measurements. In some embodiments, obtaining the urine conductivity further includes determining a urine temperature of the patient. The conductivity of urine varies with temperature, so obtaining the urine temperature can allow for temperature-based compensation of the conductivity signal, which is expected to yield more accurate urine conductivity readings. In some embodiments, prior to obtaining the urine conductivity, the method 1000 includes calibrating the one or more urine conductivity sensors and/or one or more urine sodium concentration sensors. For example, in some embodiments fluid having a known electrolyte content (e.g., saline solution with a known sodium content) is used to prime and/or flush the fluid line 119 and/or any sensors fluidly coupled thereto. Because the fluid has a known electrolyte content, readings from the urine sodium concentration sensors and/or the urine conductivity sensors can be calibrated during the flushing stage.

[0177] In block 1006, the method 1000 includes providing one or more outputs associated with a fluid therapy received by the patient. Generally, the one or more outputs can include one or more alerts or notifications provided to, e.g., a user or practitioner, and/or one or more modifications or adjustments to the patient's fluid therapy. One or more of the outputs can be based at least partially on the multiple inputs of urine output volume data (block 1002) and/or a change thereto, and/or the urine conductivity and/or sodium concentration (block 1004) and/or a change thereto. For example, if urine sodium concentration (or an indication thereof) drops, as measured indirectly by urine conductivity, the fluid therapy system may suggest one or more modifications to maintain safety and/or prevent harm to the patient. Although described as providing suggestions, those of ordinary skill in the art will appreciate that, in at least some embodiments, the one or more outputs can cause the system to automatically modify the therapy as described in the suggestion to adjust or optimize the therapy, such as by modifying the level of hydration fluid matching of urine output, modifying the diuretic dosage rate, and/or combinations thereof.

[0178] If the urine conductivity corresponds to a urine sodium concentration less than or equal to a low urine sodium concentration threshold (e.g., less than or equal to 75 mmol/L, and/or that decreases by at least 5%, 10%, 15%, 20%, 30%, and/or combinations thereof over a predetermined time period of, e.g., at least 15 minutes, 30 minutes, 1 hour, 2 hours, 6 hours, 12 hours, 24 hours, and/or combinations thereof) and the urine output is less than or equal to a low urine output threshold (e.g., a urine output rate of less than 325 mL/hr averaged over the previous 3 hours, an



integral debt function where the debt is more than 150 mL over the previous 3 hours, and/or decreases by at least 5%, 10%, 15%, 20%, 30%, and/or combinations thereof over a predetermined time period of, e.g., at least 15 minutes, 30 minutes, 1 hour, 2 hours, 6 hours, 12 hours, 24 hours, and/or combinations thereof), the one or more outputs can include an alert that the patient's urine sodium concentration is low and/or dropping, a prompt to actively monitor urine sodium, serum sodium, and/or other patient electrolytes, and/or a prompt to modify or stop the therapy. Additionally or alternatively, the alert can include one or more suggested therapy modifications, such as a change (e.g., increase) to the hydration fluid infusion rate, a change to the rate or percentage matching of infused saline to urine output, and/or a change (e.g., increase) to the rate of diuretic infusion.

**[0179]** In one example, during block **1006**, the system can adjust the hydration fluid matching percentage such that the amount of infused sodium in the infused hydration fluid matches the amount of indicated sodium that would be infused in the standard algorithm for the same volume of sodium output, assuming a high urine sodium level (e.g., 135 mmol/L). For instance, using 135 mmol/L of urine sodium as the value to normalize to, if the patient outputs 1,050 mL of urine with a measured, estimated, or calculated urine sodium concentration of 67.5 mmol/L, the urine volume with the equivalent sodium content of 135 mmol/L urine is 525 mL (i.e.,  $1050 \times 67.5 / 135 = 525$ ). In this embodiment, the saline volume replaced for 525 mL of "normalized" urine is 250 mL of normal saline, thus the 1,050 mL of urine with a sodium concentration of 67.5 mmol/L would also be replaced with 250 mL of normal saline in order to achieve the equivalent sodium balance. While urine sodium levels that exceed 135 mmol/L could be replaced with higher levels of sodium containing fluid, in other embodiments such replacement could be omitted or performed at a lesser rate to, e.g., maximize net sodium removal.

**[0180]** If the indicated urine sodium concentration is less than or equal to the low urine sodium concentration threshold and the urine output is equal to or greater than a high urine output threshold (e.g., more than 625 mL/hr averaged over the previous 3 hours, and/or increases by at least 5%, 10%, 15%, 20%, 30%, and/or combinations thereof over a predetermined time period of, e.g., at least 15 minutes, 30 minutes, 1 hour, 2 hours, 6 hours, 12 hours, 24 hours, and/or combinations thereof), the one or more outputs can include an alert that the patient's urine sodium concentration is high and/or increasing, a prompt to actively monitor urine sodium, serum sodium, and/or other patient electrolytes, and/or a prompt to modify or stop the therapy. For example, the prompt to modify the therapy can include a prompt to reduce saline matching, reduce the hydration fluid infusion rate, and/or increase the diuretic dosage rate.

**[0181]** If the indicated urine sodium concentration is less than or equal to the low urine sodium concentration threshold and the urine output is between the low urine output threshold (of, e.g., 325 mL/hr) and the high urine output threshold (of, e.g., 625 mL/hr), the one or more outputs can include an alert that the patient's urine sodium concentration is acceptable, a prompt to actively monitor urine sodium, serum sodium, and/or other patient electrolytes, and/or a prompt to continue therapy and/or that therapy modifications are not needed at this time.

**[0182]** If, on the other hand, the indicated urine sodium concentration is high, it suggests that the patient's kidney is

tolerating therapy well. More specifically, if the indicated urine sodium concentration is equal to or greater than a high urine sodium concentration threshold (e.g., greater than or equal to 100 mmol/L, and/or increases by at least 5%, 10%, 15%, 20%, 30%, and/or combinations thereof over a predetermined time period of, e.g., at least 15 minutes, 30 minutes, 1 hour, 2 hours, 6 hours, 12 hours, 24 hours, and/or combinations thereof), and the urine output is less than or equal to the low urine output threshold (of, e.g., 325 mL/hr), the one or more outputs can include a prompt to increase the diuretic dosage rate, administer an additional diuretic, and/or stop the patient's therapy.

**[0183]** If the indicated urine sodium concentration is equal to or greater than the high urine sodium concentration threshold (of, e.g., 100 mmol/L) and the urine output is equal to or greater than the high urine output threshold (of, e.g., 625 mL/hr), the one or more outputs can include a prompt to reduce hydration fluid matching, e.g., to maximize fluid and/or salt removal from the patient.

**[0184]** If the indicated urine sodium concentration is equal to or greater than the high urine sodium concentration threshold (of, e.g., 100 mmol/L) and the urine output is between the low urine output threshold (of, e.g., 325 mL/hr) and the high urine output threshold (of, e.g., 625 mL/hr), the one or more outputs can include a prompt to increase the diuretic dosage rate and/or escalate the fluid therapy. In some embodiments, when the indicated urine sodium concentration is equal to or greater than the high urine sodium concentration threshold and the urine output is between the low urine output threshold and the high urine output threshold, the one or more outputs include the prompt to increase the diuretic dosage rate and/or escalate the fluid therapy only if the urine output is decreasing. In some embodiments, the urine sodium excretion rate, which can be determined by multiplying the urine rate by the urine sodium concentration (units of mmol/hr), is another measure of the patient's urine sodium level that can be used to determine one or more of the adjustments described above. Additional details regarding adjusting fluid therapy based on urine sodium can be found in U.S. Pub. No. 2024/0260874, filed Feb. 6, 2024, and U.S. application Ser. No. 18/883,677, filed Sep. 12, 2024. Each of the above-identified applications is hereby incorporated herein by reference.

#### IV. Examples

**[0185]** Additional aspects of various embodiments of the present technology are described with reference to the following examples:

**[0186]** 1. A fluid therapy system, comprising:

**[0187]** a urine measurement device configured to measure urine output from a patient without using an indwelling catheter;

**[0188]** a pump configured to provide a diuretic or a hydration fluid to the patient; and

**[0189]** one or more processors configured to—

**[0190]** cause the pump to provide the diuretic or the hydration fluid to the patient at a fluid rate,

**[0191]** obtain, via the urine measurement device, a first input of urine output volume data from the patient,

**[0192]** obtain, via the urine measurement device, a second input of urine output volume data from the patient, wherein obtaining the second input occurs at least 15 minutes after obtaining the first input,

- [0193] determine an accumulated volume of urine output for the patient based at least partially on the first input and the second input, and
- [0194] adjust the fluid rate based at least partially on the accumulated volume of urine output.
- [0195] 2. The fluid therapy system of example 1, wherein the one or more processors are further configured to obtain, via the urine measurement device, a third input of urine output volume data from the patient, wherein obtaining the third input occurs at least 15 minutes after obtaining the second input, and wherein the accumulated volume of urine output is based at least partially on the first input, the second input, and the third input.
- [0196] 3. The fluid therapy system of example 1 or example 2, wherein:
- [0197] the fluid rate is a diuretic dosage rate;
  - [0198] the one or more processors are further configured to—
  - [0199] determine that the accumulated volume of urine output is less than a predetermined urine output volumetric threshold, and
  - [0200] recommend an increase to the diuretic dosage rate; and
  - [0201] the adjustment to the fluid rate is the recommended increase to the diuretic dosage rate.
- [0202] 4. The fluid therapy system of any of examples 1-3, wherein the one or more processors are further configured to receive an input from a user associated with transitioning the patient to use an indwelling catheter.
- [0203] 5. The fluid therapy system of any of examples 1-4, wherein the fluid rate is a first fluid rate and wherein the one or more processors are further configured to adjust the fluid rate by causing the pump to provide the hydration fluid to the patient at a second fluid rate no greater than 500 ml/hr.
- [0204] 6. The fluid therapy system of any of examples 1-5 wherein the accumulated volume is a first accumulated volume, wherein the fluid rate is a diuretic dosage rate, and wherein, to adjust the diuretic dosage rate, the one or more processors are configured to:
- [0205] cause an increase to the diuretic dosage rate by a predetermined amount and/or over a predetermined time period of no less than 120 minutes;
  - [0206] obtain, via the urine measurement device, a third input of urine output volume data from the patient,
  - [0207] obtain, via the urine measurement device, a fourth input of urine output volume data from the patient, wherein obtaining the fourth input occurs at least 15 minutes after obtaining the third input;
  - [0208] determine a second accumulated volume of urine output based at least partially on the third input and the fourth input;
  - [0209] determining whether the second accumulated volume of urine output data is greater than a urine output volumetric threshold; and
  - [0210] when the second accumulated volume of urine output data is greater than the urine output volumetric threshold, stop the increase to the diuretic dosage rate.
- [0211] 7. The fluid therapy system of any of examples 1-6 wherein:
- [0212] the first input and the second input are obtained over a second time period;
  - [0213] the fluid rate is a hydration fluid rate; and
  - [0214] the one or more processors are configured to—
  - [0215] adjust the hydration fluid rate by causing a second amount of hydration fluid to be administered to the patient, wherein the second amount is a predetermined percentage of the accumulated volume; and
  - [0216] during a first time period before the second time period—
  - [0217] obtain, via the urine measurement device, a third input of urine output volume data from the patient,
  - [0218] obtain, via the urine measurement device, a fourth input of urine output volume data from the patient, wherein obtaining the fourth input occurs at least 15 minutes after obtaining the third input, and
  - [0219] cause a first amount of hydration fluid to be administered to the patient, wherein the first amount is equal to a total urine output volume during the first time period up to a hydration fluid threshold.
- [0220] 8. A method for providing fluid therapy to a patient, the method comprising:
- [0221] obtaining multiple inputs of urine output volume data from the patient without using an indwelling catheter, wherein the multiple inputs include a first input obtained at a first time, and a second input obtained at a second time at least 30 minutes after the first time;
  - [0222] determining an accumulated volume of urine output for the patient based at least partially on the multiple inputs; and
  - [0223] adjusting a hydration fluid rate at which a hydration fluid is provided to the patient and/or a diuretic dosage rate at which a diuretic is provided to the patient based at least partially on the accumulated volume of urine output.
- [0224] 9. The method of example 8, wherein obtaining the multiple inputs of urine output volume data includes obtaining the multiple inputs of urine output volume data via an external catheter.
- [0225] 10. The method of example 8 or example 9, further comprising determining a urine output rate by considering the second input and time elapsed between the second time and the first time.
- [0226] 11. The method of any of examples 8-10, wherein adjusting the hydration fluid rate and/or the diuretic dosage rate is based at least partially on the accumulated volume and/or the multiple inputs from at least a prior 60 minutes.
- [0227] 12. The method of any of examples 8-11, wherein the multiple inputs include a volume of urine at or above a minimum urine volume threshold of 50 milliliters.
- [0228] 13. The method of any of examples 8-12, wherein the multiple inputs are received no less than 60 minutes apart from one another.
- [0229] 14. The method of examples 8-13, further comprising receiving an input from a user associated with transitioning the patient to using an indwelling catheter.
- [0230] 15. One or more non-transitory computer-readable medium having instructions that, when executed by one or more processors, cause a fluid therapy system to perform operations comprising:
- [0231] obtaining multiple inputs of urine output volume data from a patient without using an indwelling catheter, wherein the multiple inputs include a first input

- obtained at a first time, and a second input obtained at a second time at least 30 minutes after the first time;
- [0232] determining an accumulated volume of urine output for the patient based at least partially on the multiple inputs; and
- [0233] adjusting a hydration fluid rate at which a hydration fluid is provided to the patient and/or a diuretic dosage rate at which a diuretic is provided to the patient based at least partially on the accumulated volume of urine output.
- [0234] 16. The one or more non-transitory computer-readable medium of example 15, wherein the multiple inputs further include a third input obtained at a third time at least 30 minutes after the first time.
- [0235] 17. The one or more non-transitory computer-readable medium of example 15 or example 16, wherein adjusting the hydration fluid rate and/or the diuretic dosage rate is based at least partially on the accumulated volume and/or the multiple inputs from at least a prior 60 minutes.
- [0236] 18. The one or more non-transitory computer-readable medium of any of examples 15-17, wherein the operations further comprise:
- [0237] infusing the diuretic to the patient at the diuretic dosage rate; and
- [0238] only after obtaining the multiple inputs of urine output volume data from the patient, infusing the hydration fluid to the patient at the hydration fluid rate based on the multiple inputs.
- [0239] 19. The one or more non-transitory computer-readable medium of any of examples 15-18, wherein the operations further comprise receiving an input from a user associated with transitioning the patient to an indwelling catheter.
- [0240] 20. The one or more non-transitory computer-readable medium of any of examples 15-19, wherein:
- [0241] determining the accumulated volume of urine output includes adding the first input to the second input;
- [0242] obtaining the multiple inputs includes obtaining the multiple inputs over a time period;
- [0243] the operations further comprise determining an estimated urine output rate for the patient over the time period by dividing the accumulated volume of urine output by the time period; and
- [0244] adjusting the hydration fluid rate and/or the diuretic dosage rate is based at least partially on the estimated urine output rate.

## V. Conclusion

[0245] It will be apparent to those having skill in the art that changes may be made to the details of the above-described embodiments without departing from the underlying principles of the present technology. In some cases, well known structures and functions have not been shown or described in detail to avoid unnecessarily obscuring the description of the embodiments of the present technology. Although blocks of methods may be presented herein in a particular order, alternative embodiments may perform the blocks in a different order. Similarly, certain aspects of the present technology disclosed in the context of particular embodiments can be combined or eliminated in other embodiments. Furthermore, while advantages associated with certain embodiments of the present technology may have been disclosed in the context of those embodiments,

other embodiments can also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages or other advantages disclosed herein to fall within the scope of the technology. Accordingly, the disclosure and associated technology can encompass other embodiments not expressly shown or described herein, and the invention is not limited except as by the appended claims.

[0246] Throughout this disclosure, the singular terms “a,” “an,” and “the” include plural referents unless the context clearly indicates otherwise. Similarly, unless the word “or” is expressly limited to mean only a single item exclusive from the other items in reference to a list of two or more items, then the use of “or” in such a list is to be interpreted as including (a) any single item in the list, (b) all of the items in the list, or (c) any combination of the items in the list. Additionally, the term “comprising,” “including,” and “having” should be interpreted to mean including at least the recited feature(s) such that any greater number of the same feature and/or additional types of other features are not precluded.

[0247] Reference herein to “one embodiment,” “an embodiment,” “some embodiments” or similar formulations means that a particular feature, structure, operation, or characteristic described in connection with the embodiment can be included in at least one embodiment of the present technology. Thus, the appearances of such phrases or formulations herein are not necessarily all referring to the same embodiment. Furthermore, various particular features, structures, operations, or characteristics may be combined in any suitable manner in one or more embodiments.

[0248] Unless otherwise indicated, all numbers expressing concentrations, pressures, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about.” As used herein, the use of relative terminology, such as “about,” “approximately,” “substantially” and the like refer to the stated value plus or minus ten percent. For example, the use of the term “about 100” refers to a range of from 90 to 110, inclusive. In instances in which the context requires otherwise and/or relative terminology is used in reference to something that does not include a numerical value, the terms are given their ordinary meaning to one skilled in the art. Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present technology. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Additionally, all ranges disclosed herein are to be understood to encompass any and all subranges subsumed therein. For example, a range of “1 to 10” includes any and all subranges between (and including) the minimum value of 1 and the maximum value of 10, i.e., any and all subranges having a minimum value of equal to or greater than 1 and a maximum value of equal to or less than 10, e.g., 5.5 to 10.

[0249] The disclosure set forth above is not to be interpreted as reflecting an intention that any claim requires more features than those expressly recited in that claim. Rather, as the following claims reflect, inventive aspects lie in a combination of fewer than all features of any single foregoing disclosed embodiment. Thus, the claims following

this Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment. This disclosure includes all permutations of the independent claims with their dependent claims.

I/We claim:

1. A fluid therapy system, comprising:
  - a urine measurement device configured to measure urine output from a patient without using an indwelling catheter;
  - a pump configured to provide a diuretic or a hydration fluid to the patient; and
  - one or more processors configured to—
    - cause the pump to provide the diuretic or the hydration fluid to the patient at a fluid rate,
    - obtain, via the urine measurement device, a first input of urine output volume data from the patient,
    - obtain, via the urine measurement device, a second input of urine output volume data from the patient, wherein obtaining the second input occurs at least 15 minutes after obtaining the first input,
    - determine an accumulated volume of urine output for the patient based at least partially on the first input and the second input, and
    - adjust the fluid rate based at least partially on the accumulated volume of urine output.
2. The fluid therapy system of claim 1, wherein the one or more processors are further configured to obtain, via the urine measurement device, a third input of urine output volume data from the patient, wherein obtaining the third input occurs at least 15 minutes after obtaining the second input, and wherein the accumulated volume of urine output is based at least partially on the first input, the second input, and the third input.
3. The fluid therapy system of claim 1, wherein:
  - the fluid rate is a diuretic dosage rate;
  - the one or more processors are further configured to—
    - determine that the accumulated volume of urine output is less than a predetermined urine output volumetric threshold, and
    - recommend an increase to the diuretic dosage rate; and
  - the adjustment to the fluid rate is the recommended increase to the diuretic dosage rate.
4. The fluid therapy system of claim 1, wherein the one or more processors are further configured to receive an input from a user associated with transitioning the patient to use an indwelling catheter.
5. The fluid therapy system of claim 1, wherein the fluid rate is a first fluid rate and wherein the one or more processors are further configured to adjust the fluid rate by causing the pump to provide the hydration fluid to the patient at a second fluid rate no greater than 500 ml/hr.
6. The fluid therapy system of claim 1 wherein the accumulated volume is a first accumulated volume, wherein the fluid rate is a diuretic dosage rate, and wherein, to adjust the diuretic dosage rate, the one or more processors are configured to:
  - cause an increase to the diuretic dosage rate by a predetermined amount and/or over a predetermined time period of no less than 120 minutes;
  - obtain, via the urine measurement device, a third input of urine output volume data from the patient,
  - obtain, via the urine measurement device, a fourth input of urine output volume data from the patient, wherein

- obtaining the fourth input occurs at least 15 minutes after obtaining the third input;
  - determine a second accumulated volume of urine output based at least partially on the third input and the fourth input;
  - determining whether the second accumulated volume of urine output data is greater than a urine output volumetric threshold; and
  - when the second accumulated volume of urine output data is greater than the urine output volumetric threshold, stop the increase to the diuretic dosage rate.
7. The fluid therapy system of claim 1 wherein:
    - the first input and the second input are obtained over a second time period;
    - the fluid rate is a hydration fluid rate; and
    - the one or more processors are configured to—
      - adjust the hydration fluid rate by causing a second amount of hydration fluid to be administered to the patient, wherein the second amount is a predetermined percentage of the accumulated volume; and
      - during a first time period before the second time period—
        - obtain, via the urine measurement device, a third input of urine output volume data from the patient,
        - obtain, via the urine measurement device, a fourth input of urine output volume data from the patient, wherein obtaining the fourth input occurs at least 15 minutes after obtaining the third input, and
        - cause a first amount of hydration fluid to be administered to the patient, wherein the first amount is equal to a total urine output volume during the first time period up to a hydration fluid threshold.
  8. A method for providing fluid therapy to a patient, the method comprising:
    - obtaining multiple inputs of urine output volume data from the patient without using an indwelling catheter, wherein the multiple inputs include a first input obtained at a first time, and a second input obtained at a second time at least 30 minutes after the first time;
    - determining an accumulated volume of urine output for the patient based at least partially on the multiple inputs; and
    - adjusting a hydration fluid rate at which a hydration fluid is provided to the patient and/or a diuretic dosage rate at which a diuretic is provided to the patient based at least partially on the accumulated volume of urine output.
  9. The method of claim 8, wherein obtaining the multiple inputs of urine output volume data includes obtaining the multiple inputs of urine output volume data via an external catheter.
  10. The method of claim 8, further comprising determining a urine output rate by considering the second input and time elapsed between the second time and the first time.
  11. The method of claim 8, wherein adjusting the hydration fluid rate and/or the diuretic dosage rate is based at least partially on the accumulated volume and/or the multiple inputs from at least a prior 60 minutes.
  12. The method of claim 8, wherein the multiple inputs include a volume of urine at or above a minimum urine volume threshold of 50 milliliters.
  13. The method of claim 8, wherein the multiple inputs are received no less than 60 minutes apart from one another.

**14.** The method of claim **8**, further comprising receiving an input from a user associated with transitioning the patient to using an indwelling catheter.

**15.** One or more non-transitory computer-readable medium having instructions that, when executed by one or more processors, cause a fluid therapy system to perform operations comprising:

obtaining multiple inputs of urine output volume data from a patient without using an indwelling catheter, wherein the multiple inputs include a first input obtained at a first time, and a second input obtained at a second time at least 30 minutes after the first time; determining an accumulated volume of urine output for the patient based at least partially on the multiple inputs; and

adjusting a hydration fluid rate at which a hydration fluid is provided to the patient and/or a diuretic dosage rate at which a diuretic is provided to the patient based at least partially on the accumulated volume of urine output.

**16.** The one or more non-transitory computer-readable medium of claim **15**, wherein the multiple inputs further include a third input obtained at a third time at least 30 minutes after the first time.

**17.** The one or more non-transitory computer-readable medium of claim **15**, wherein adjusting the hydration fluid rate and/or the diuretic dosage rate is based at least partially on the accumulated volume and/or the multiple inputs from at least a prior 60 minutes.

**18.** The one or more non-transitory computer-readable medium of claim **15**, wherein the operations further comprise:

infusing the diuretic to the patient at the diuretic dosage rate; and

only after obtaining the multiple inputs of urine output volume data from the patient, infusing the hydration fluid to the patient at the hydration fluid rate based on the multiple inputs.

**19.** The one or more non-transitory computer-readable medium of claim **15**, wherein the operations further comprise receiving an input from a user associated with transitioning the patient to an indwelling catheter.

**20.** The one or more non-transitory computer-readable medium of claim **15**, wherein:

determining the accumulated volume of urine output includes adding the first input to the second input;

obtaining the multiple inputs includes obtaining the multiple inputs over a time period;

the operations further comprise determining an estimated urine output rate for the patient over the time period by dividing the accumulated volume of urine output by the time period; and

adjusting the hydration fluid rate and/or the diuretic dosage rate is based at least partially on the estimated urine output rate.

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