

## CLAIMS

1. A catheter system, comprising:

a catheter adapter, comprising a distal end and a proximal end;

a catheter, comprising a distal end, a proximal end, a catheter lumen extending through the distal end of the catheter and the proximal end of the catheter, and an inner surface forming the catheter lumen, wherein the catheter extends distally from the distal end of the catheter adapter, wherein the distal end of the catheter comprises a hole;

an introducer needle extending through the catheter, wherein the introducer needle comprises a distal end, a proximal end, an introducer needle lumen extending through the distal end of the introducer needle and the proximal end of the introducer needle, and an inner surface forming the introducer needle lumen, wherein the distal end comprises a sharp distal tip; and

a gap disposed between an outer surface of the introducer needle and the inner surface of the catheter and within the catheter lumen, wherein the gap is in fluid communication with the hole such that in response to the hole being inserted into a vein, blood may flow through the hole and into the gap; and

a bio-impedance sensor, wherein the bio-impedance sensor comprises a first electrode and a second electrode, wherein the first electrode is embedded in the inner surface of the introducer needle at the distal end of the introducer needle or an outer surface of the catheter at the distal end of the catheter within the gap, wherein the second electrode is configured to be secured to skin of a patient.

2. The catheter system of claim 1, wherein the gap is annular.

~~3. The catheter system of claim 1, wherein the introducer needle comprises a groove, wherein a distal end of the groove is proximate the hole, wherein the gap is disposed within the groove.~~

~~4. The catheter system of claim 3, wherein the hole is a first hole, wherein the groove is a first groove, wherein the distal end of the catheter comprises a second hole, wherein the second hole is proximal to the first hole, wherein a distal end of the second groove is proximate the second hole.~~

~~5. The catheter system of claim 1, wherein the introducer needle comprises a distal end, a proximal end, a introducer needle lumen extending through the distal end of the introducer needle and the proximal end of the introducer needle, and an inner surface forming the introducer~~

needle lumen, further comprising a sensor embedded in the inner surface of the introducer needle at the distal end of the introducer needle, wherein the sensor is configured to detect the distal end of the introducer needle is within the vein.

6. — The catheter system of claim 5, wherein the sensor comprises a bio-impedance sensor, a pressure sensor, a capacitance sensor, or an infrared sensor.

7.3. — The catheter system of claim 5, further comprising a plurality of other sensors, wherein the sensor and the plurality of other sensors comprise bio-impedance sensors, wherein the bio-impedance sensor and the plurality of other sensors are aligned with a bevel of the introducer needle.

8. — The catheter system of claim 1, further comprising a sensor embedded in the outer surface of the catheter at the distal end of the catheter and proximate the gap, wherein the sensor is configured to detect the distal end of the catheter is within the vein.

9. — The catheter system of claim 8, wherein the sensor comprises a bio impedance sensor, a pressure sensor, a capacitance sensor, or an infrared sensor.

10. — The catheter system of claim 1, wherein the introducer needle comprises a distal end, a proximal end, an introducer needle lumen extending through the distal end of the introducer needle and the proximal end of the introducer needle, and an inner surface forming the introducer needle lumen, further comprising an bio impedance sensor, wherein the bio impedance sensor comprises a first electrode and a second electrode, wherein the first electrode is embedded in the inner surface of the introducer needle at the distal end of the introducer needle or the outer surface of the catheter at the distal end of the catheter within the gap, wherein the second electrode is configured to be secured to skin of a patient.

11. — A catheter system, comprising:

a catheter adapter, comprising a distal end and a proximal end;

~~a catheter, comprising a distal end, a proximal end, a catheter lumen extending through the distal end and the proximal end, and an inner surface forming the catheter lumen, wherein the distal end comprises a distal opening, wherein the catheter extends distally from the distal end of the catheter adapter, wherein the inner surface of the catheter comprises a plurality of channels extending from the distal opening; and~~

~~an introducer needle extending through the distal opening, wherein the introducer needle comprises a sharp distal tip, wherein the plurality channels are configured to allow blood to flow between an outer surface of the introducer needle and the inner surface of the catheter in response to the distal end of the catheter being inserted into a vein.~~

12. — ~~The catheter system of claim 11, wherein the introducer needle comprises a distal end, a proximal end, an introducer needle lumen extending through the distal end of the introducer needle and the proximal end of the introducer needle, and an inner surface forming the introducer needle lumen, further comprising a sensor embedded in the inner surface of the introducer needle at the distal end of the introducer needle, wherein the sensor is configured to detect the distal end of the introducer needle is within the vein.~~

13. — ~~The catheter system of claim 11, further comprising a sensor embedded in the outer surface of the catheter at the distal end of the catheter and proximate the gap, wherein the sensor is configured to detect the distal end of the catheter is within the vein.~~

14. — ~~A catheter system, comprising:~~

~~a catheter adapter, comprising a distal end and a proximal end;~~

~~a catheter, comprising a distal end, a proximal end, a catheter lumen extending through the distal end and the proximal end, and an inner surface forming the catheter lumen, wherein the~~

~~catheter extends distally from the distal end of the catheter adapter, wherein the distal end of the catheter comprises a distal opening;~~

~~an introducer needle extending through the distal opening, wherein the introducer needle comprises a sharp distal tip;~~

~~a first position indicator configured to indicate the introducer needle is inserted into a vein; and~~

~~a second position indicator configured to indicate the catheter is inserted into the vein.~~

15. — ~~The catheter system of claim 14, wherein the second position indicator is configured to indicate the catheter is inserted into the vein a first amount, further comprising a third position indicator configured to indicate the catheter is inserted within the vein a second amount.~~

16. — ~~The catheter system of claim 14, wherein the first position indicator comprises a notch disposed within the introducer needle and proximate a gap disposed between an outer surface of the introducer needle and an inner surface of the catheter, wherein the second position indicator comprises a marking disposed on an outer surface of the catheter.~~

17. — ~~The catheter system of claim 16, wherein the third indicator comprises:~~

~~a lumen disposed within a wall of the catheter and an aperture at a distal end of the lumen, wherein the aperture extends through the wall;~~

~~a groove within an outer surface of the introducer needle and a hole at a distal end of the groove extending through the wall of the catheter;~~

~~a sensor embedded in an outer surface of the catheter; or~~

~~a marking disposed on an outer surface of the catheter.~~

18. — ~~The catheter system of claim 14, wherein the first position indicator comprises:~~

~~a sensor embedded within an inner surface of the introducer needle; or~~

~~a notch disposed within the introducer needle and proximate a gap disposed between an outer surface of the introducer needle and an inner surface of the catheter.~~

~~19. The catheter system of claim 18, wherein the first position indicator comprises the notch, wherein the first position indicator further comprises an absorbent material disposed within the notch.~~

~~20. The catheter system of claim 14, wherein the second indicator comprises:~~

~~a hole disposed within the distal end of the catheter and in fluid communication with a gap disposed between an outer surface of the introducer needle and an inner surface of the catheter;~~

~~a channel extending from the distal opening and in fluid communication with the gap disposed between the outer surface of the introducer needle and the inner surface of the catheter;~~

~~a sensor embedded in an outer surface of the catheter;~~

~~a channel within an outer surface of the introducer needle and in fluid communication with the gap disposed between the outer surface of the introducer needle and the inner surface; or~~

~~a marking disposed on an outer surface of the catheter.~~