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;

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 inner surface of the catheter at the distal end of the catheter proximate 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, 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.