

Claims

What is claimed is:

1. An apparatus for confirming placement of a hollow-bore structure at a desired treatment location in a mammalian subject, comprising:
 - a first sensor operably connected to a lumen disposed in the hollow-bore structure, the first sensor configured to provide a first signal in response to detection of a first property indicative of a cardiac pulse in the lumen of the hollow-bore structure;
 - a second sensor configured to provide a second signal in response to detection of a second property indicative of the cardiac pulse; and
 - a controller operably connected to the first and second sensors to receive the first and second signals, the controller configured to compare the first and second signals to provide a comparison result, whereby the comparison result provides an indication of placement of the hollow-bore structure relative to the desired treatment location.
2. The apparatus of claim 1, wherein the hollow-bore structure comprises one or more of a needle and a catheter.
3. The apparatus of any one of the preceding claims, wherein the first sensor comprises an in-line pressure sensor having a sensor lumen disposed in fluid communication with the lumen of the hollow-bore structure.
4. The apparatus of any one of the preceding claims, wherein the first sensor is disposed in fluid communication with the lumen of the hollow-bore structure.
5. The apparatus of any one of the preceding claims, wherein the second sensor comprises a finger pulse sensor.
6. The apparatus of any one of the preceding claims, wherein the first physical property is one or more of a pressure, change in fluid volume, an electrical signal, and an optical signal.
7. The apparatus of any one of the preceding claims, wherein the second physical property is one or more of a pressure, change in fluid volume, an electrical signal, and an optical signal.

8. The apparatus of any one of the preceding claims, wherein the first and second properties relate to the same physical property.
9. The apparatus of any one of claims 1–7, wherein the first and second properties relate to different physical properties.
10. The apparatus of any one of the preceding claims, wherein the controller is disposed in wireless communication with one or more of the first and second sensors.
11. The apparatus of any one of the preceding claims, wherein one or more of the first and second sensors includes a memory configured to store an indication that the first or second sensor, respectively, has been used.
12. The apparatus of any one of the preceding claims, comprising an identification circuit embedded within or connected to one or more of the first and second sensors, wherein the identification circuit is configured to provide a signal to the controller, the signal including one or more of: a configuration signal indicative of physical characteristics of the first or second sensor; a verification signal indicative of the first or second sensor; and a use signal so that the controller can detect the number of times or length of time the first or second sensor was previously used.
13. An apparatus for confirming placement of a hollow-bore structure at a desired treatment location in a mammalian subject, comprising a controller configured to receive a first signal from a first detector placed at the treatment location, the first signal indicative of a cardiac pulse in the hollow-bore structure, and configured to receive a second signal indicative of the cardiac pulse from a second detector placed at a second location, the controller programmed to compare the first and second signals to provide a comparison result, whereby the comparison result provides an indication of placement of the hollow-bore structure relative to the desired treatment location.
14. The apparatus of any one of the preceding claims, wherein the first signal represents one or more of a pressure, change in fluid volume, an electrical signal, and an optical signal.

15. The apparatus of any one of the preceding claims, wherein the second signal represents one or more of a pressure, change in fluid volume, an electrical signal, and an optical signal.
16. The apparatus of any one of the preceding claims, wherein the first signal has a first period and the second signal has a second period, and wherein the controller is configured to compare the first and second periods to provide the comparison result.
17. The apparatus of any one of the preceding claims, wherein the first signal comprises a waveform having a first period and the second signal comprises a waveform having a second period, and wherein the controller is configured to compare the first and second periods to provide the comparison result.
18. The apparatus of any one of the preceding claims, wherein the first signal comprises a first numeric value indicative of a frequency of the first signal, and the second signal comprises a second numeric value indicative of a frequency of the second signal, and wherein the controller is configured to compare the first and second numeric values.
19. The apparatus according to claim 18, wherein one or more of the first and second numeric values is a cardiac pulse in beats per minute.
20. The apparatus of any one of the preceding claims, wherein the controller is configured to determine if the first and second signals are correlated to provide the comparison result.
21. The apparatus of any one of the preceding claims, wherein one or more of the first and second signals each comprise a respective waveform having a respective period and having a respective mean value, and wherein the controller is configured to detect zero-crossings of each of the respective waveforms through the respective mean value.
22. The apparatus of any one of the preceding claims, wherein the controller is configured to create an alert signal when the comparison result is within a selected value.

23. The apparatus of any one of the preceding claims, comprising a display operably connected to the controller for receiving one or more of the first and second signals and the comparison result from the controller.
24. The apparatus of any one of claims 1–22, wherein the controller includes a display.
25. The apparatus of claim 23 or 24, wherein the display includes a first data section for displaying a pressure versus time in the lumen of the hollow-bore structure.
26. The apparatus of any one of claims 23–25, wherein the display includes a second data section for displaying the first and second signals.
27. The apparatus of claim 26, wherein the first and second signals each include a respective waveform, and wherein the second data section includes a graph displaying as a function of time the respective waveforms of the first and second signals.
28. The apparatus of any one of claims 23–27, wherein the display includes a section for displaying an alert indication when the comparison result is within a selected value.
29. The apparatus of claim 28, wherein the alert is one or more of an auditory, visual, and haptic signal.
30. The apparatus of any one of the preceding claims, wherein the controller is programmed to perform a cross-correlation analysis of the first and second signals.