

thetia. One important aspect of the pressure-flow characteristic is compliance. Static compliance is defined as the increase of lung volume divided by the increase in pressure used to create that increased volume. Existing lung models implement compliance with springs and/or compressible gas chambers. That type of modeling makes computer control over compliance cumbersome. In the instant patient simulator, compliance is a variable in the controlling computer and can be rapidly changed via computer.

The lung volumes are realized by mechanical bellows **100**. The volume of the bellows **100** is derived from the excursion sensor **118** attached to each of the two bellows **100** (although, as previously noted, only one is shown). Based on the excursions, respective lung volumes are computed. The double acting pneumatic piston **112** (one for each lung) then creates a volume dependent downward force on the bellows **100** due to a differential in pressure from the EPR **108** versus the MPR **110** that is equivalent to the computer **16** force that would be opposing inflation due to the lung compliance.

The means for accomplishing non-linear compliances is through the use of the double acting piston **112**. One side of the piston is exposed to a bias pressure from a manual pressure regulator (MPR) **110** while the other side of the piston is exposed to a pressure from an electronic pressure regulator (EPR) **108**. The EPR **108** is computer controlled via a digital-to-analog (D/A) line (not shown). The D/A line is supplied with the muscle pressure signal described elsewhere herein. Thus, in addition to normal lung activities and compliances, a cough may be simulated by suddenly lowering the pressure of the EPR **108** below that of the bias pressure of the MPR **110**.

Thus, the present invention discloses a method of simulating non-linear compliances in real time in an integrated patient simulator **1** during simulated medical procedures using a manikin **4**. The method includes the step of first computing the volume of at least one bellows **100**. Volume is preferably determined via the excursion sensor **118** output described elsewhere herein. Based on the volume reading and optionally a reading from the pressure sensors **101** situated in the lung the compliances may be modeled. The modeling itself is embodied in the use of a bellows actuating means which has a first constant pressure from an MPR **110** and a second variable pressure from an EPR **108** acting on respective sides of a double acting piston **112** capable of actuating the bellows **100** whereby varying the second variable pressure causes the bellows **100** to exhibit the desired compliance force on the bellows **100** according to a time- and event-based script, a computer model or a combination of a time- and event-based script and a computer model based on the physiological state of the patient simulator **1**.

In generating a compliance, the volume measured by the excursion sensor **118** is used as one input in a predetermined mathematical compliance formula dictated by the physiological model. The output of the mathematical compliance formula is the desired or target lung pressure.

What is claimed is:

1. An apparatus for injecting and volatilizing a volatile drug in real time in an integrated patient simulator during simulated medical procedures, comprising:

- a. a manikin;
- b. a supply of gas;
- c. at least one output device associated with the manikin;
- d. means for volatilizing a volatile drug administered to the manikin, wherein the drug volatilizing means comprises a thermal conductor defining a gas propagating

cavity disposed therethrough and a sintered insert disposed within the gas propagating cavity, the thermal conductor further defining a needle accepting cavity which communicates the exterior of the thermal conductor with the interior of the insert, wherein the needle accepting cavity is capable of accepting a hypodermic needle such that the tip of the hypodermic needle is in contact with the sintered insert when the needle is fully inserted into the volatilizing means, and wherein the gas propagating cavity is capable of permitting the flow of the gas therethrough such that the drug upon evaporation in the sintered insert is carried through the gas propagating cavity by the supply of gas flowing continuously therethrough;

e. a conduit interconnecting the supply of gas with the gas propagating cavity; and

f. programmed computing means associated with the volatilizing means for calculating a simulated response to the drug and for actuating the output device to simulate the effects of the drug according to a time- and event-based script, a computer model or a combination of a time- and event-based script and a computer model based on the physiological state of the patient simulator.

2. The apparatus of claim **1**, wherein the sintered insert is comprised of brass and the thermal conductor comprises a cylinder of copper.

3. The apparatus of claim **1**, further comprising a drug analyzing means for identifying the drug administered to the manikin.

4. The apparatus of claim **1**, further comprising a computer controlled syringe pump for administering the drug to the manikin.

5. A method of simulating a physiological response to a drug in real time in an integrated patient simulator during simulated medical procedures using a manikin, comprising the steps of:

a. directing a volatile drug to a manikin which has a drug volatilizing means, wherein the drug volatilizing means comprises a thermal conductor defining a gas propagating cavity disposed therethrough and a sintered insert disposed within the gas propagating cavity, the thermal conductor further defining a needle accepting cavity which communicates the exterior of the thermal conductor with the interior of the insert, wherein the needle accepting cavity is capable of accepting a hypodermic needle such that the tip of the hypodermic needle is in contact with the sintered insert when the needle is fully inserted into the receiving means;

b. flowing a gas through the gas propagating cavity such that the drug upon evaporation on the sintered insert is carried through the gas propagating cavity by the gas to an analyzing means;

c. detecting by the analyzing means the kind of drug administered; and

d. utilizing the kind of drug administered in computing a simulated response on at least one output device associated with the manikin so as to provide a simulated response in accordance with an appropriate physiological response to the drug.

6. The method of claim **5**, wherein the step of directing a volatile drug to the manikin comprises administering the drug via a computer controlled syringe pump.

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