Califia Perfusion Simulator

Getting Started with Califia Perfusion Simulator

March 2023

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US Patent No.	14051442
European Patent No.	2906107
Canadian Patent No.	2887344
Singapore Patent No.	11201502855X
Chinese Patent No.	ZL 201380062871X
US Patent Pending	PCT/US2018/012009

Califia® is in conformity with the following standards

EVS-EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements.
EVS-EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General Requirements

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Image Source: www.biomedsimulation.com

Table of Contents

1

Introduction to the Califia Perfusion Simulator

The Califia Perfusion Simulator system can simulate a patient before, during and after CardioPulmonary Bypass (CPB) for open heart surgery or long-term support with ExtraCorporeal Membrane Oxygenation (ECMO).

1.1 Components of the Califia Perfusion Simulator

The three components of the Califia Perfusion Simulator, shown in Figure 1.1, are the **Califia Patient Module (CPM)**, the **Laptop Computer** and the **Touchscreen Monitor**. Apply power to each component.

The CPM connects to the Laptop Computer using an ethernet cable. Two cables connect the Touchscreen Monitor to the laptop, an HDMI cable and a USB cable.

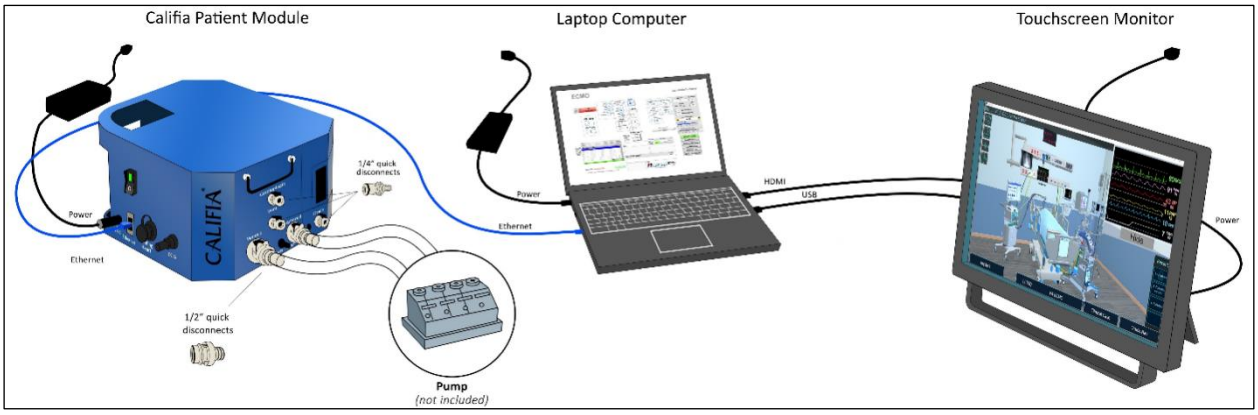

Figure 1.1 Califia Perfusion Simulator Setup

The CPM hydraulic ports, Figure 1.2, connect to either a Heart Lung Machine (HLM), in the case of CPB, or an ECMO system.

CPM hydraulic ports	Description
Arterial	*Main delivery port into the CPM. It connects to the oxygenator outflow line.*
Venous	*The CPM's venous drainage port. It connects to a venous reservoir in the case of CPB or directly to the pump's inlet port in ECMO circuits.*
Cardioplegia	*Secondary delivery port into the CPM. Used for Cardioplegia during CPB or a second delivery port in hybrid ECMO configurations.*
Vent	*Secondary drainage port. During CPB, it can connect to the Left Ventricle Vent pump.*
Drain	*Tertiary drainage port. It is used to drain the CPM's reservoir during the teardown process.*
Overflow	*It provides runoff should the CPM's reservoir overfill.*

Figure 1.2 CPM Hydraulic Ports

1.2 CPM connections for Cardiopulmonary Bypass (CPB)

Figure 1.3 illustrates connections from a simplified CPB circuit to the CPM. Table 1.1 summarizes these connections.

HLM	CPM
Systemic blood pump	Arterial
Venous Reservoir	Venous
Cardioplegia delivery	Cardioplegia
LV Vent pump	Vent

Table 1.1 HLM connections to CPM

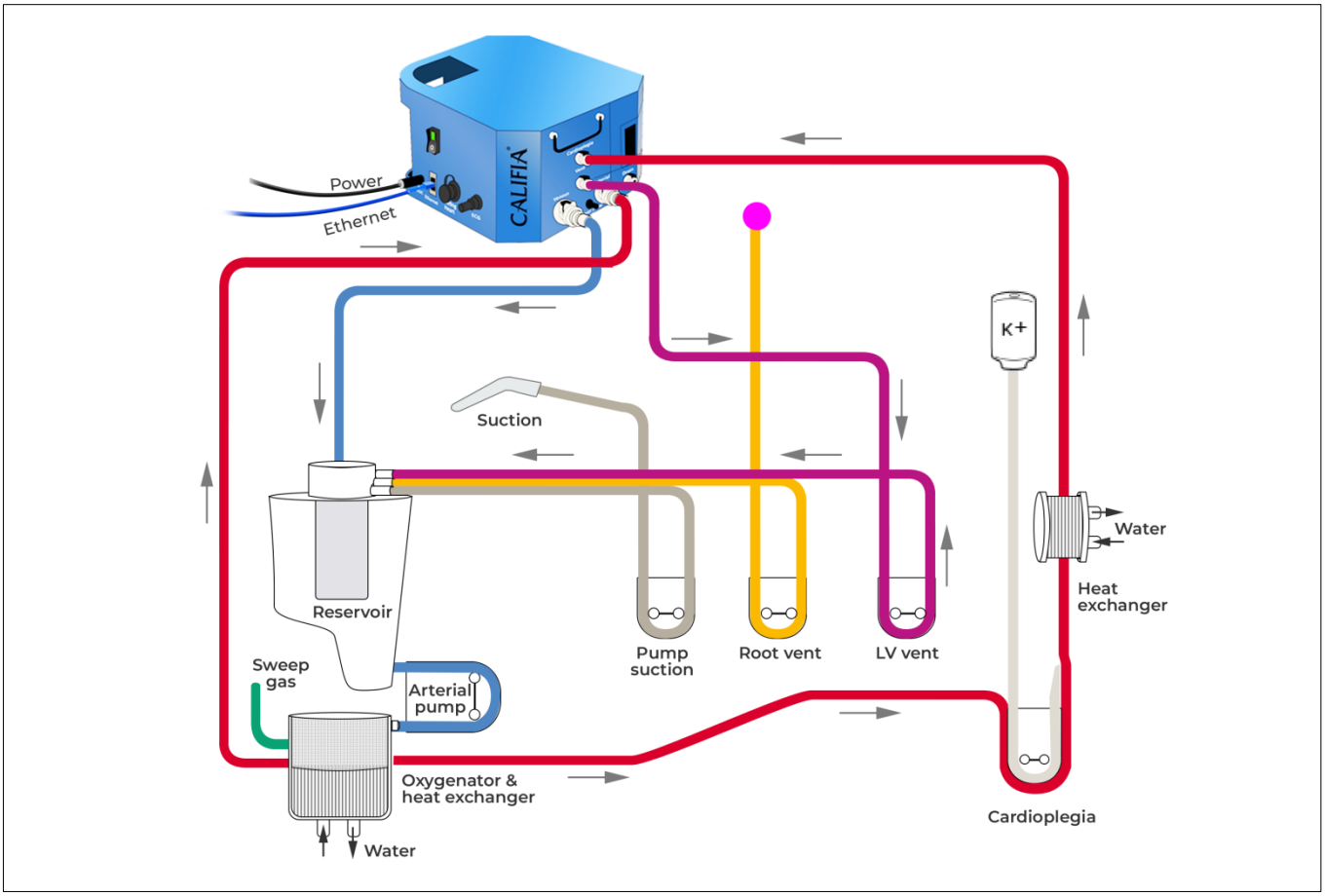

Figure 1.3 HLM connections to CPM

Note - If the Vent port is not used, connect a ¼" tubing segment and clamp it.

1.3 CPM connections for ECMO

1.3.1 **VA ECMO** - Figure 1.4 illustrates connections between a VA ECMO circuit and the CPM. Table 1.2 summarizes these connections.

ECMO	CPM	NOTES
Oxygenator output port	Arterial	
ECMO Pump inlet	Venous	
	Cardioplegia	Connect these together
	Vent	

Table 1.2 VA ECMO connections to CPM

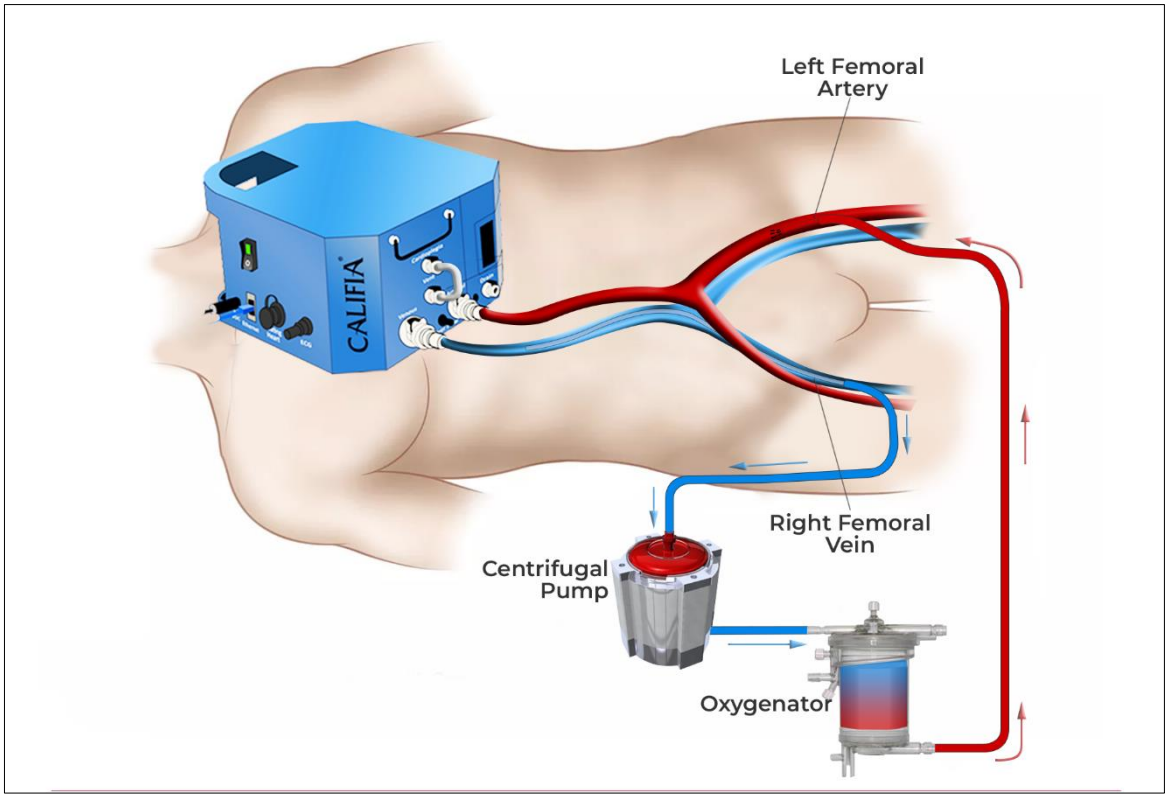

Figure 1.4 VA ECMO with CPM

1.3.2 **VV ECMO** --Figure 1.5, illustrates connections between a VV ECMO circuit and the CPM. Table 1.3 summarizes these connections.

ECMO	CPM	NOTES
Oxygenator output port	Arterial	
ECMO Pump inlet	Venous	
	Cardioplegia	Connect these together
	Vent	

Table 1.3 VV ECMO connections to CPM

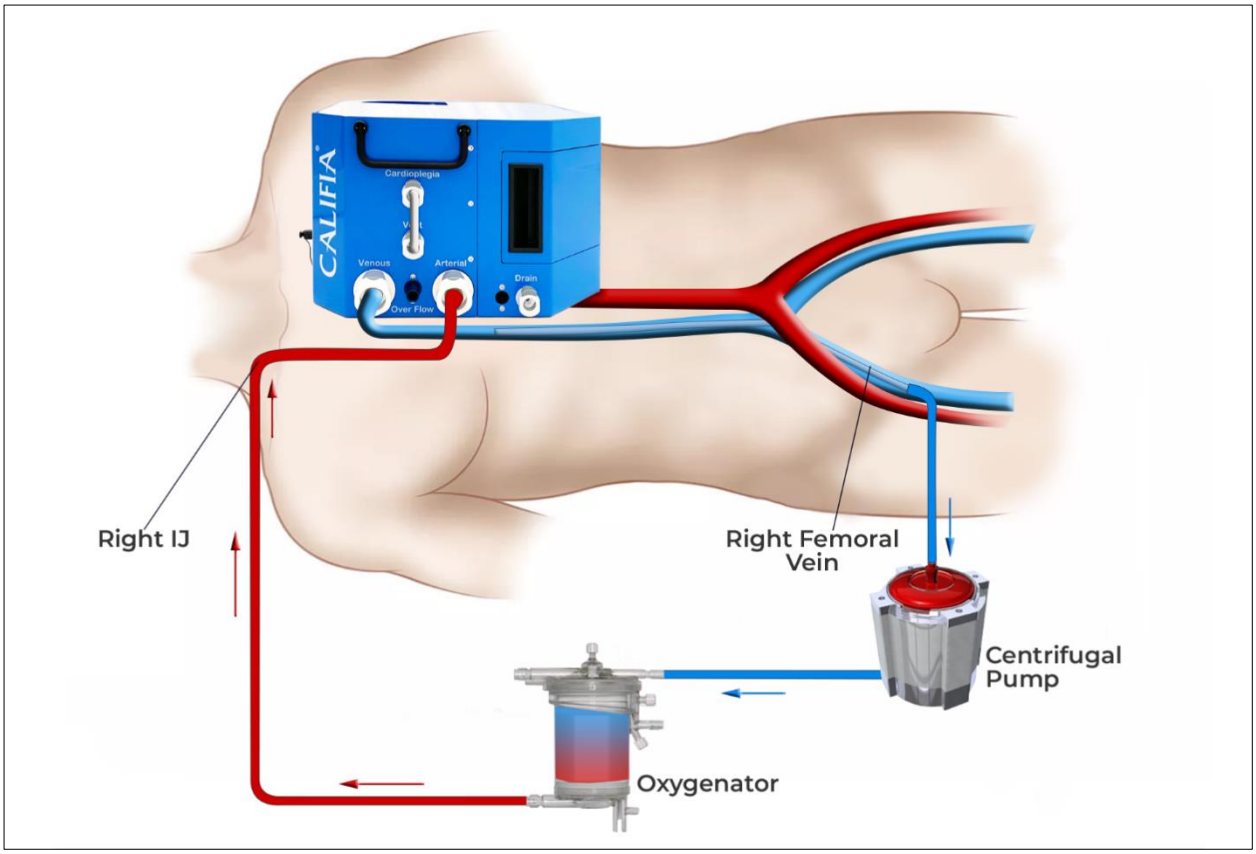

Figure 1.5 VV ECMO with CPM

The same CPM connections apply for VV ECMO **IJ-Fem** or **IJ-IJ** (Dual Lumen).

1.3.3 **VAV ECMO** -Figure 1.6 illustrates connections between a VAV ECMO circuit and the CPM. Table 1.4 summarizes these connections.

ECMO	CPM	NOTES
Delivery main branch	Arterial	
ECMO Pump inlet	Venous	
Delivery IJ branch	Cardioplegia	
	Vent	Clamped tubing

Table 1.4 VAV ECMO connections with CPM

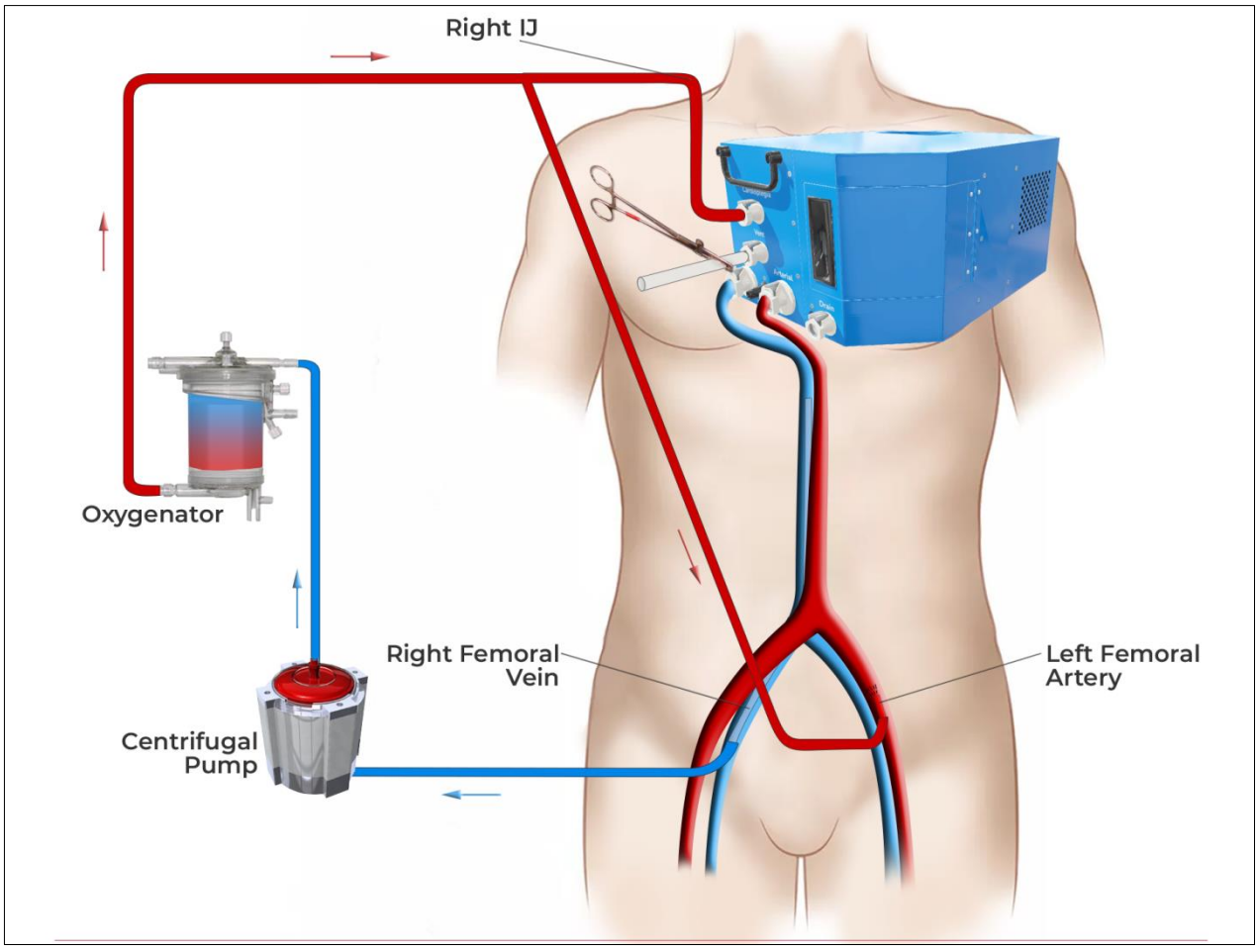

Figure 1.6 VAV ECMO with CPM

The same CPM connections apply for VAV ECMO **IJ-Fem-Fem** or **IJ-IJ-Fem** (Dual Lumen in IJ).

2

A brief tour of the Califia Simulator software

To launch the Califia Simulator software, double-click the Califia Simulator icon located in the computer's desktop. Refer to Figure 2.1.

Figure 2.1 Califia Simulator desktop icon

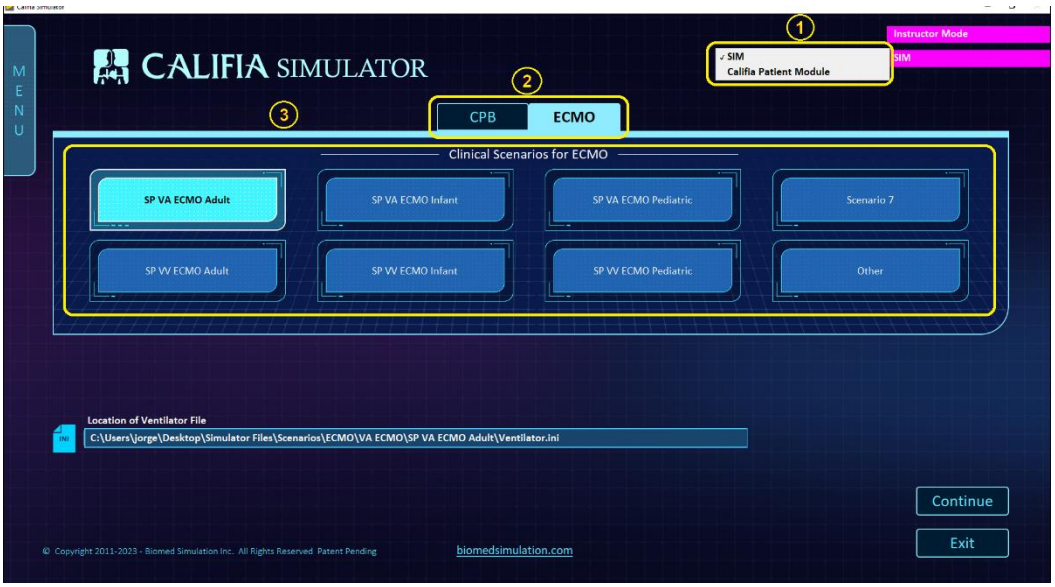

Figure 2.2 Califia Simulator Opening Screen

2.1 Modes of Simulation: SIM and CPM

Refer to ① in Figure 2.2.

SIM	this mode does not use the Califia Patient Module. All relevant equipment, Heart Lung Machine (HLM) in CPB or ECMO circuit in ECMO, is virtualized and made accessible in the software.
Califia Patient Module	this mode uses the CPM and real life support equipment such as an HLM or ECMO circuit. If the Califia Simulator software detects the CPM present, this selection becomes available.

2.2 Modes of Operation: CPB and ECMO

Refer to ② in Figure 2.2

Select either **CPB** or **ECMO** to step into the selected simulation application. The next step is to select a clinical simulation scenario then press the **Continue** button on the lower right of the window.

2.3 Clinical Scenario files

Refer to ③ in Figure 2.2.

Many of the buttons in the **Clinical Scenarios** section provide easy links to scenario files. For this Getting Started process, we will use one of the Standardized Patient scenarios.

For **CPB**, select the button labeled **SP CPB Adult**.

For **ECMO**, select the button labeled **SP VA ECMO Adult**.

Either of these simulation scenarios will configure the patient as an adult in need of either CPB or VA ECMO support respectively.

2.4 Instructor's Panel

Figure 2.3 shows the Instructor's Panel for CPB and ECMO side-by-side.

These panels have a similar layout. The CPB Instructor's Panel shows its space divided into sections.

① refers to common numerical indicators and entry fields such as blood gas sampling values.

② is the scenario file and steps section.

③ shows the grouping of text fields.

④ displays a different top half based on the button selection.

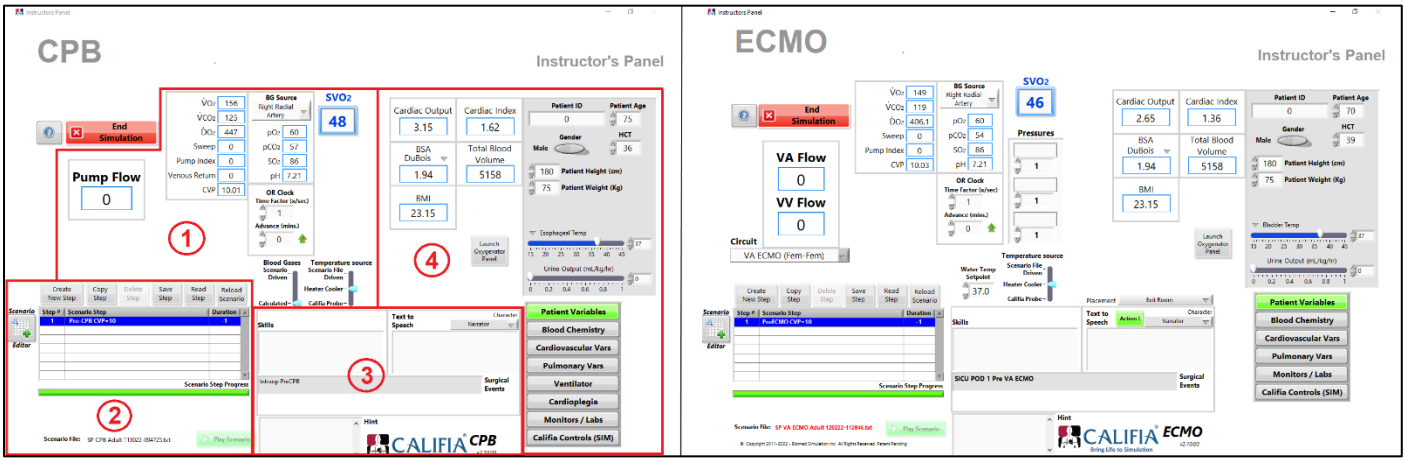

Figure 2.3 Instructor's Panels for CPB and ECMO respectively

2.5 Learner Screen

Figure 2.4 shows the Learner Screen for CPB and ECMO side-by-side.

As in the case of the Instructor's Panels, these screens have a similar layout. Refer to the numbers in the image for the following descriptions

① displays the patient's vital signs in the form of traces as well as numerically

② is an area used to display relevant medical device panels like inline blood gas analyzers, heater-coolers and clotting timers.

③ is a blood sampling report. This is a floating panel that can be moved to different locations. There are other similar floating panels available for either CPB or ECMO.

④ refers to the gas blender elements: Sweep and Oxygenator FiO2.

⑤ is the bottom ribbon with access to panels and options such as Alarms and Media panels.

⑥ is shown in the ECMO learner screen and refers to the Ventilator settings area.

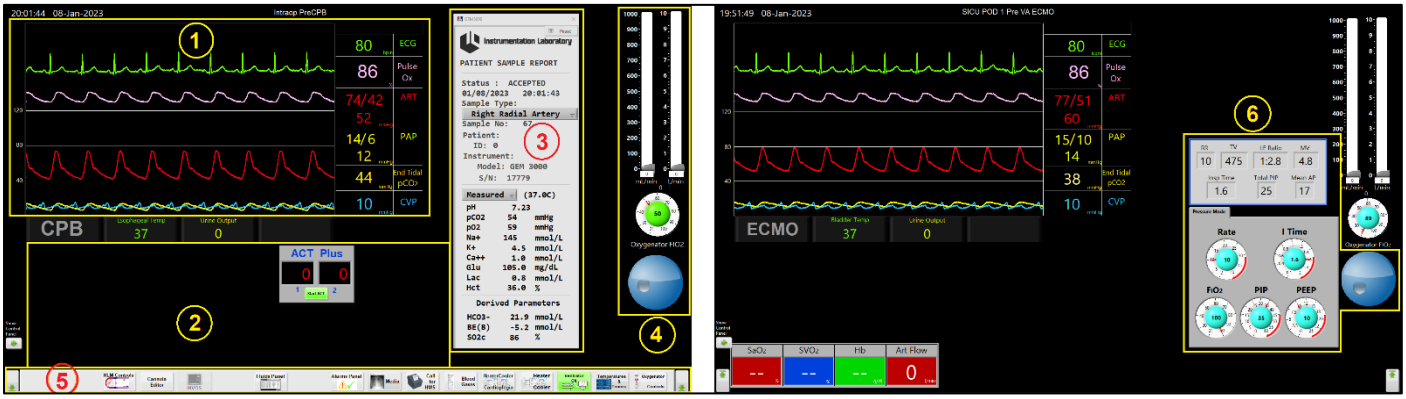

Figure 2.4 Learner Screen for CPB and ECMO respectively

2.6 The Califia 3D ICU environment (ECMO only)

Figure 2.5 shows the 3D Intensive Care Unit (ICU), available for ECMO simulation. The learner can navigate the environment and interact with the medical devices in the space.

Figure 2.5 Califia 3D ICU (ECMO only)

3

Prepare the Califia Patient Module

3.1 Priming CPM

Power ON the CPM, wait about 30 seconds and select the **Califia Patient Module** simulation mode in the Opening Screen, then press **Continue** to step into either CPB or ECMO per your preference.

Prepare the CPM with tubing connections as shown in Figure 3.1 image ①.

- The Arterial and Venous ports attach to ½" or ⅜" tubing.
- The Cardioplegia and Vent ports attach to ¼" tubing (*not shown*).
- Make each tubing segment at least 6" in length. Clamp all tubing to avoid leaking water.

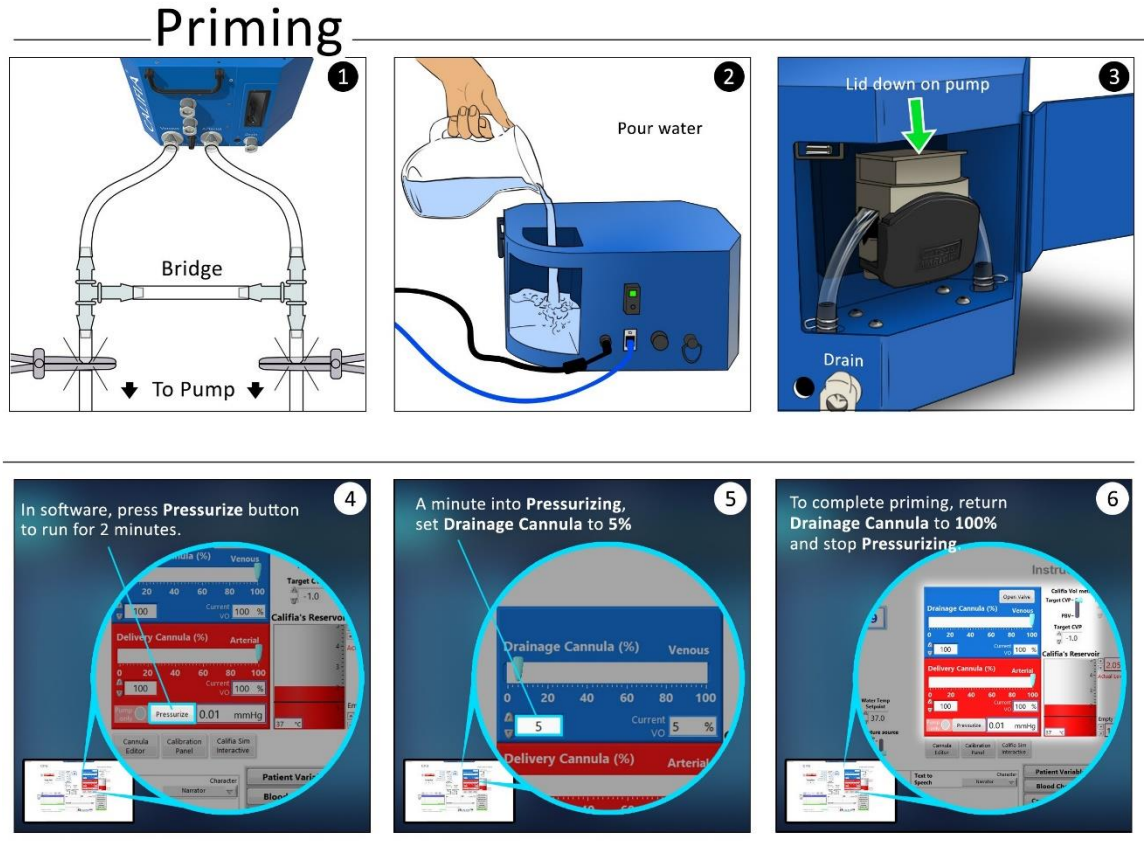

Figure 3.1 CPM priming process

Refer to Figure 3.1 to prime the CPM.

① Connect a tubing circuit with a bridge section between the **Venous** and **Arterial** ports. Clamp the segments connected to the pump.

② Pour about 2.5 Liters of water into the CPM's reservoir.

- Notice patient's vitals such as arterial pressure and central venous pressure increase in value; in essence, the vitals correspond to those of a living patient.
- Ensure all tubing is clamped to avoid any water leak

③ Open side door to align the silicon tubing in peristaltic pump's raceway. Close lid and side door.

DO NOT OPERATE PERISTALTIC PUMP WHILE ADJUSTING TUBING

④ In the **Instructor's Panel** » **Califia Controls** section, press the **Pressurize** button to operate the peristaltic pump and prime the CPM.

⑤ After one minute of pressurizing, set **Drainage Cannula** value to **5%**.

⑥ After an additional minute, complete the priming process by returning the **Drainage Cannula** value to **100%** and pressing the **Pressurizing** button to stop the peristaltic pump.

To achieve high flow rates at lower pressure place the CPM at least 18" higher than the venous reservoir (CPB) or pump inlet (ECMO).

3.2 Return to the Opening Screen

If you wish to choose a different simulation scenario as instructed in one of the next three sections, press the **End Simulation** button in the Instructor's Panel to return to the Opening Screen.

4

Let’s go on pump! – a CPB simulation

This chapter steps through a CPB simulation. You can follow along.

Approximately 60 minutes to complete this chapter.

4.1 SIM vs Califia Patient Module

Refer to Figure 4.1, ①.

SIM	Sections in this chapter headlined with this image refer to software-only simulation. No CPM or real pump is involved.
Califia Patient Module	Sections in this chapter headlined with this image use a Heart Lung Machine connected to the CPM.

4.2 Use a Standardized Patient scenario

Select one of the three SP CPB scenarios available, Figure 4.1, ②:

- SP CPB Adult
- SP CPB Infant
- SP CPB Pediatric

Press **Continue** button**,** ③**,** to step into the simulation.

Figure 4.1 Opening Screen » CPB mode

4.3 Patient Demographics

Refer to Figure 4.2 review and change the following:

① **Age**

② **HCT**

③ **Gender**

④ **Weight**

⑤ **Height**

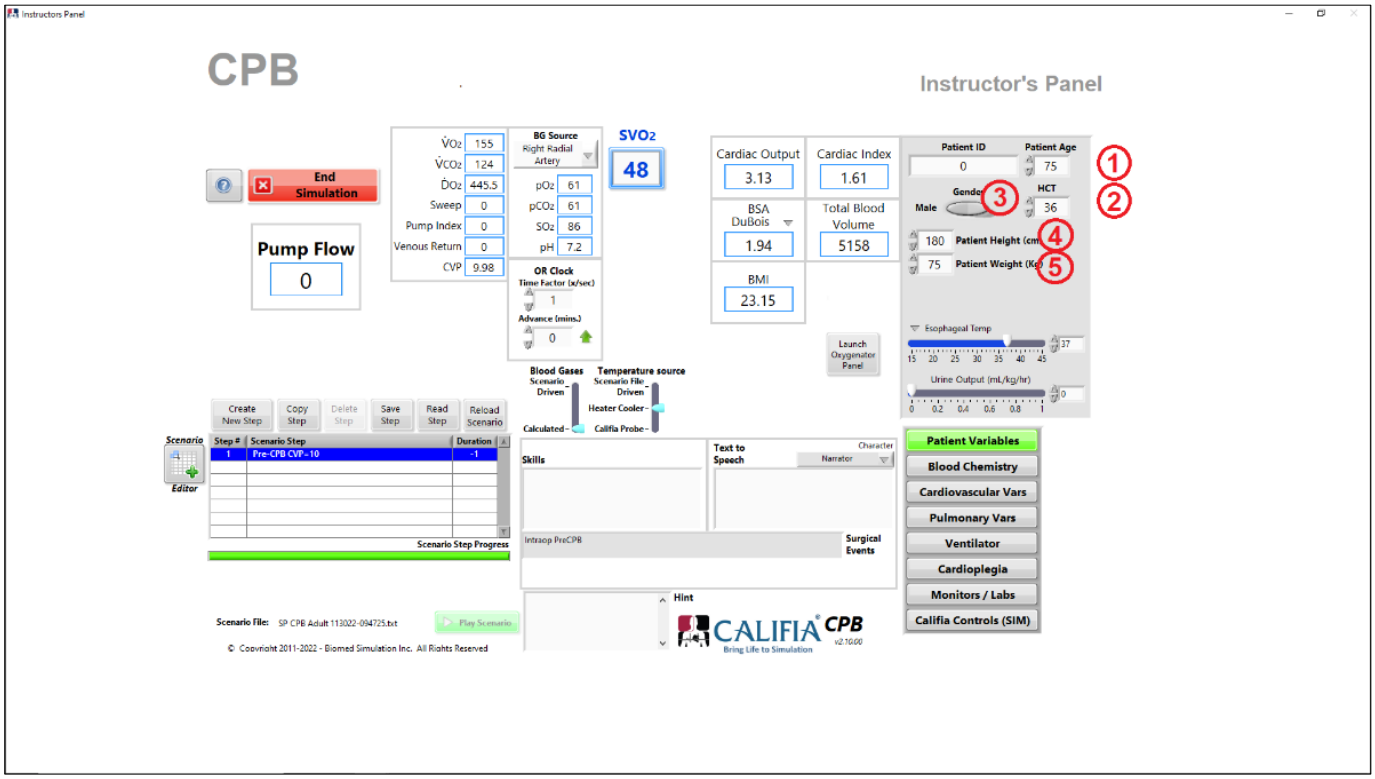

Figure 4.2 Patient demographics in Instructor's Panel

4.4 CVP Gain

In **Instructor's Panel,** press the **Calibration Panel** button under **Califia Controls** to bring up the **Califia Calibration Panel**, Figure 4.3. Set **CVP Gain** as dictated in Table 4.1

BSA (m^2)	CVP Gain
< 1	3.5
Between 1 & 2	3.0
> 2	2.5

Table 4.1 BSA vs CVP Gain

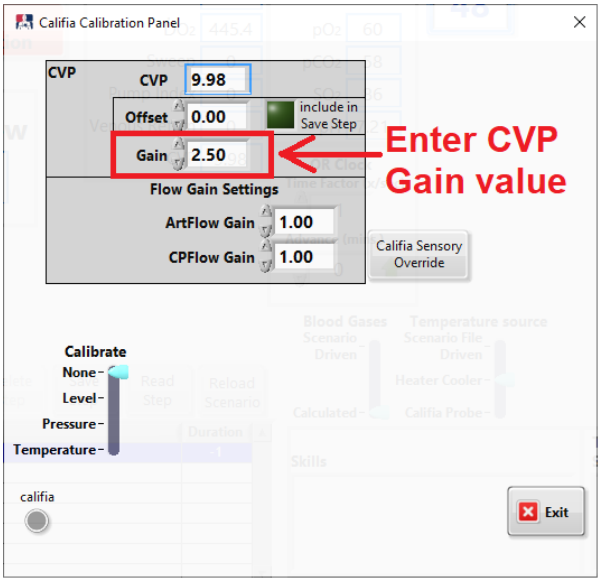

Figure 4.3 Califia Calibration Panel » CVP Gain

4.5 CVP

Set CVP to 10 mmHg

Califia Patient Module

Fill **Califia's Reservoir** until **CVP** is **10** *mmHg*, ① in Figure 4.4.

It's acceptable if the CVP is ± 0.20 of 10 mmHg.

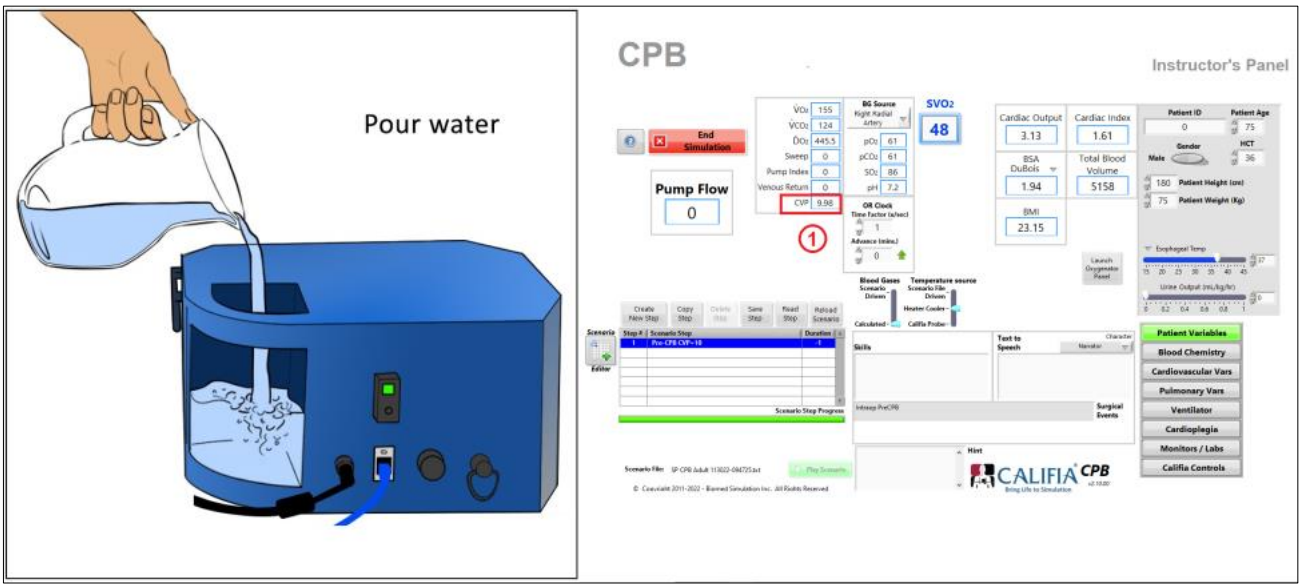

Figure 4.4 Fill CPM with water to match target CVP

SIM

Refer to Figure 4.5, go to **Instructor's Panel » Califia Controls**

① Enter **10** for **Target CVP** then press <*Enter*> .

② Volume in the virtual **Califia's Reservoir** changes until **CVP** reaches 10, ③.

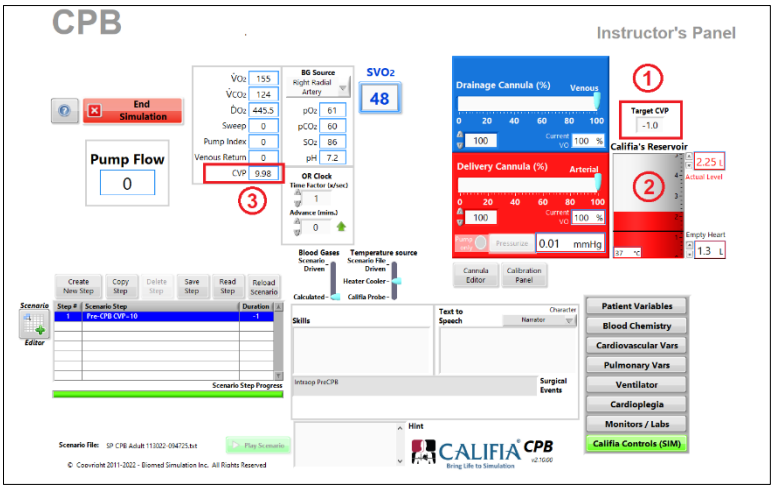

Figure 4.5 Set Target CVP in SIM mode

4.6 Arterial Pressure

Refer to Figure 4.6, in **Instructor's Panel** » **Cardiovascular Vars**,

① Press **Set Arterial Pressure** button.

② Specify desired **Systolic** and **Diastolic** Arterial Pressures.

③ Press **Target** button.

④ It takes a few seconds to find values for **LV Contractility** and **SVR**.

⑤ Once Targetting is complete, press **Save Step** to save all changes to scenario file.

Close **Model Settings** panel upon saving changes to scenario file.

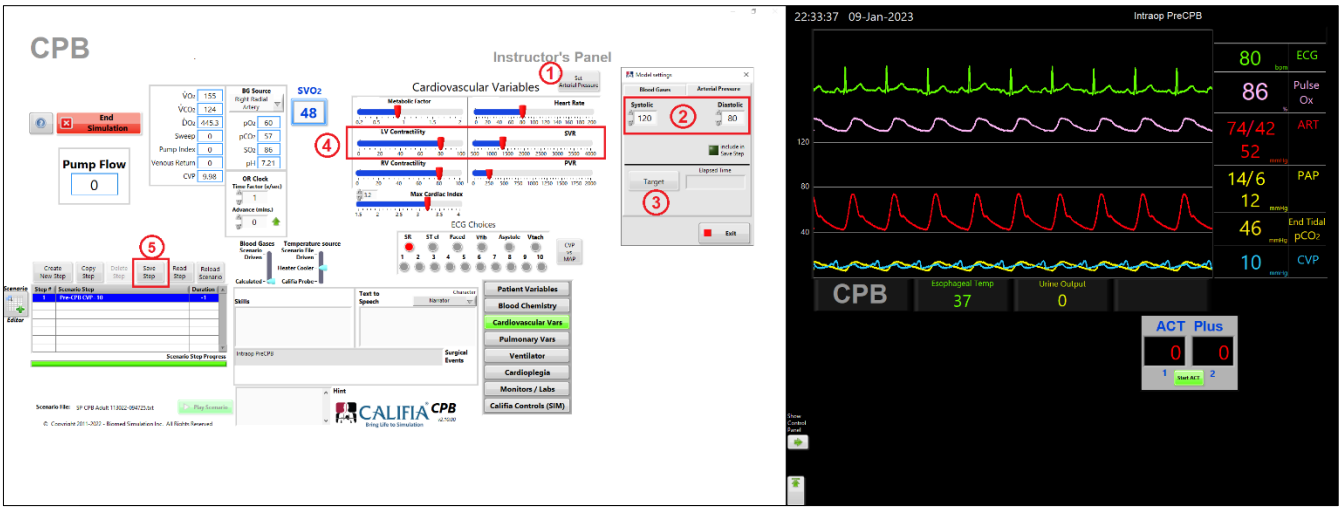

Figure 4.6 Set Systolic and Diastolic Arterial Pressure

4.7 Blood Gases

Refer to Figure 4.7, in **Instructor's Panel** » **Blood Chemistry**.

① Press **Calculate Desired Gases** button.

② Specify desired **pO2**, **pCO2** and **pH** for arterial blood.

③ Press **Target** button.

④ It takes several minutes to find values for **HCO3-**, **Dead Space** and **Pulmonary Shunt Fraction**.

The last two parameters are in the **Pulmonary Vars** section.

⑤ Once Targetting is complete, press **Save Step** to save all changes to scenario file.

Close **Model Settings** panel upon saving changes to scenario file.

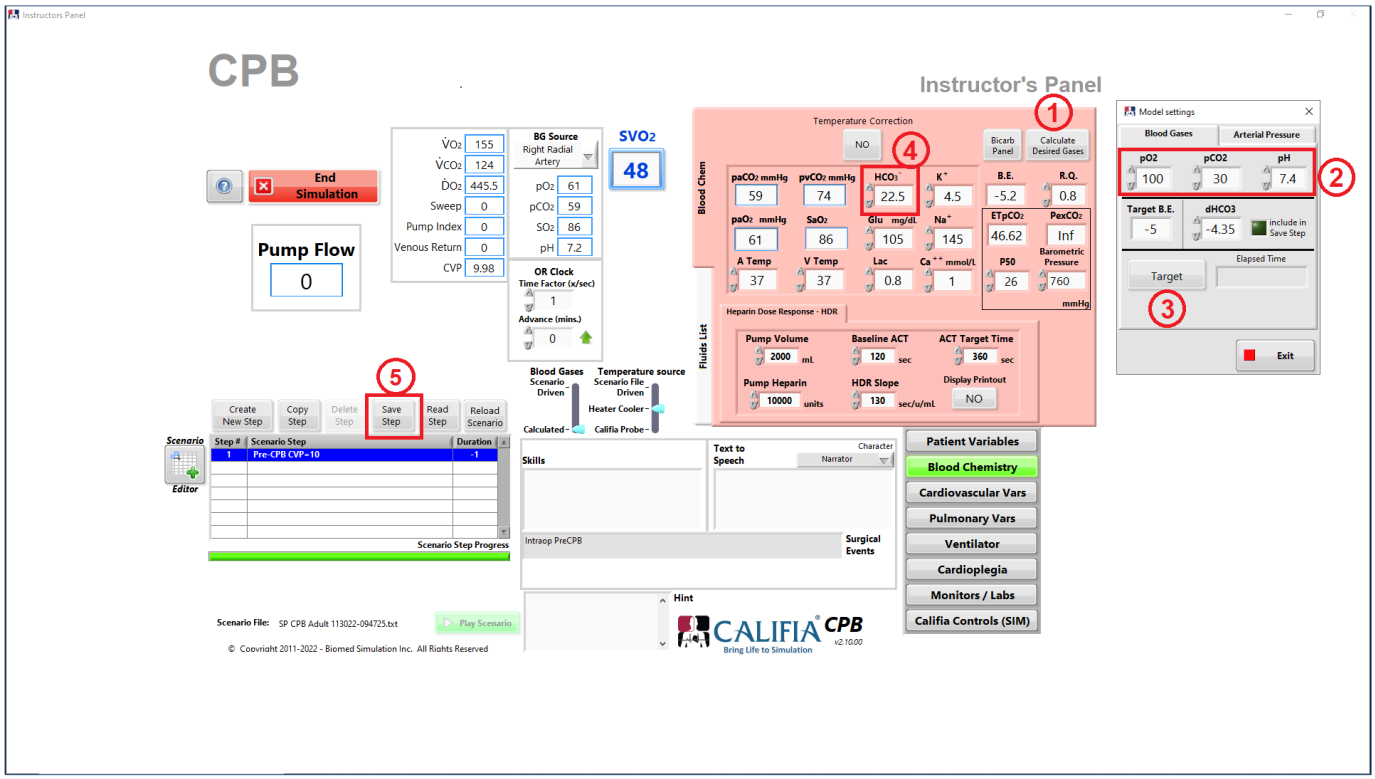

Figure 4.7 Set Blood Gases

4.8 Select Delivery and Drainage Cannulas

Refer to Figure 4.8 to select Delivery (arterial) and Drainage (venous) Cannulas. In **Instructor's Panel** » **Califia Controls**,

① Press **Cannula Editor** button.

②**a** In **Cannula Editor**, select a **Delivery Cannula** from drop-down list then press **Apply** button.

③**a** Cannula label and corresponding valve opening is shown.

②**b** Change to **Drainage Cannula**, select cannula from drop-down list then press **Apply** button.

③**b** Cannula label and corresponding valve opening is shown.

Exit Cannula Editor.

Pressure-Flow profiles for cannulas are modeled using respective electro-mechanical valves in CPM. The same performance profiles are used in SIM mode.

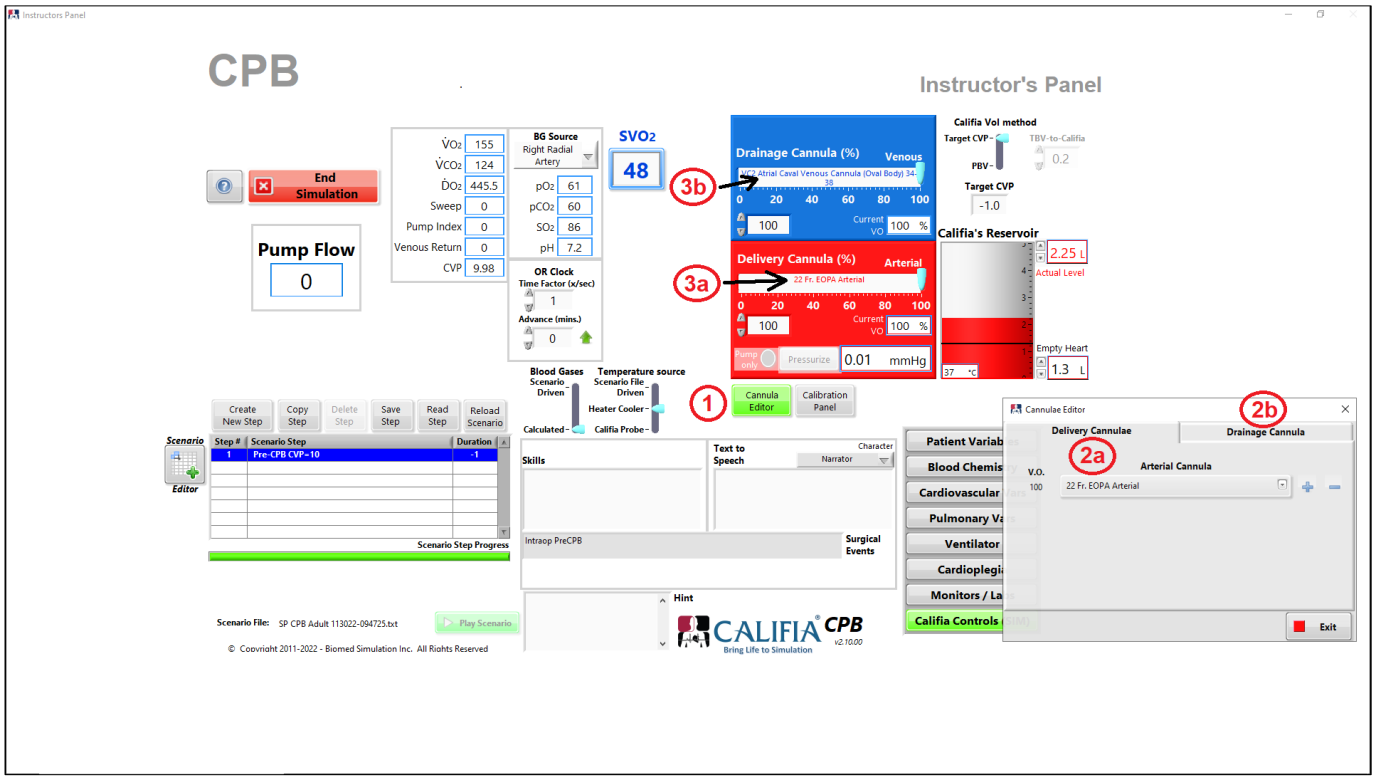

Figure 4.8 Cannula selection

4.9 Set Gas Blender

Refer to Figure 4.9, gas blender settings are set in the learner screen.

① Bring up bottom ribbon and select **Oxygenator Controls** button.

② Set **Gas Sweep Rate**, say ***2*** *LPM*.

③ Set **Oxygenator FiO_2** to ***100%*** by pressing green button then turning blue knob.

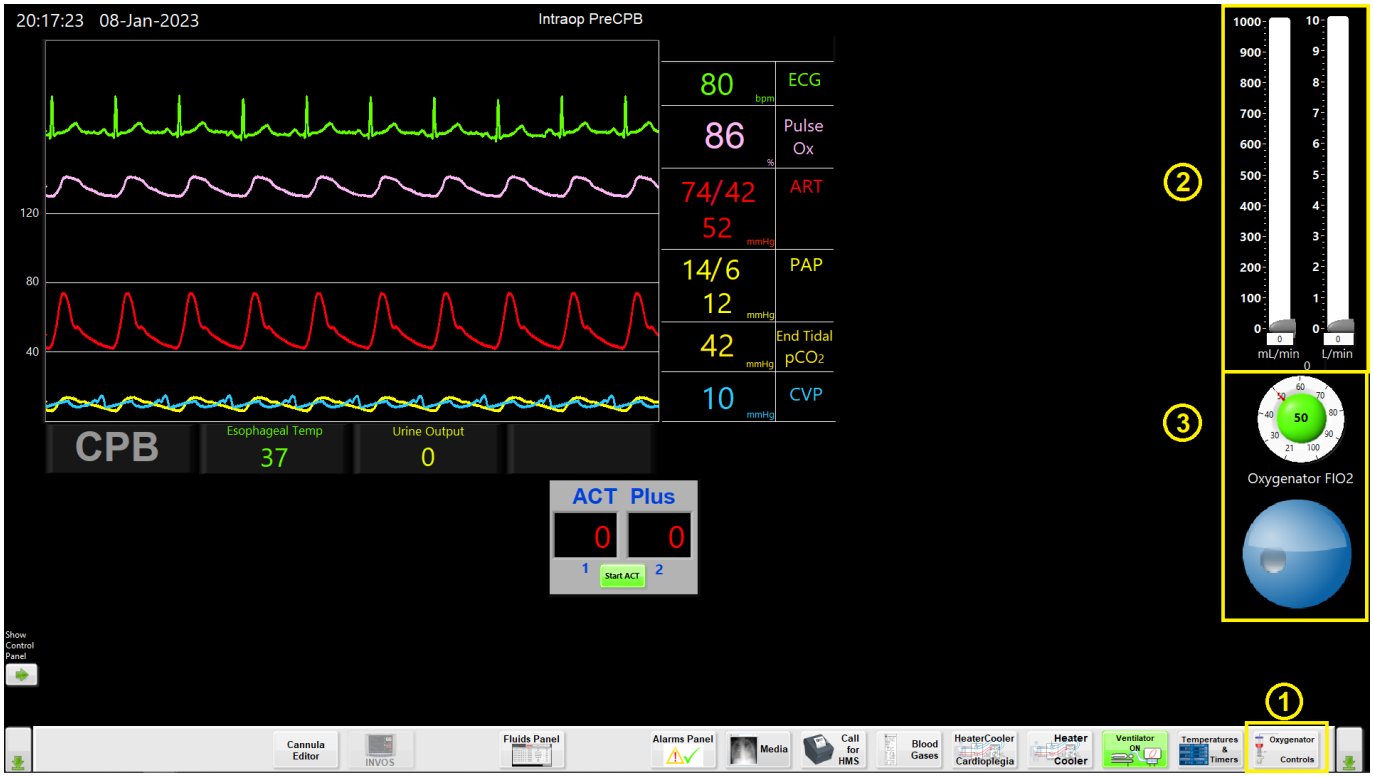

Figure 4.9 Set Gas Blender

4.10 Let’s go on pump!

Califia Patient Module

Remove clamp on venous drainage line to drain patient while flowing using systemic pump.

Notice **Arterial Pressure** and **CVP** values decreasing as patient transitions support to heart lung machine, Figure 4.10.

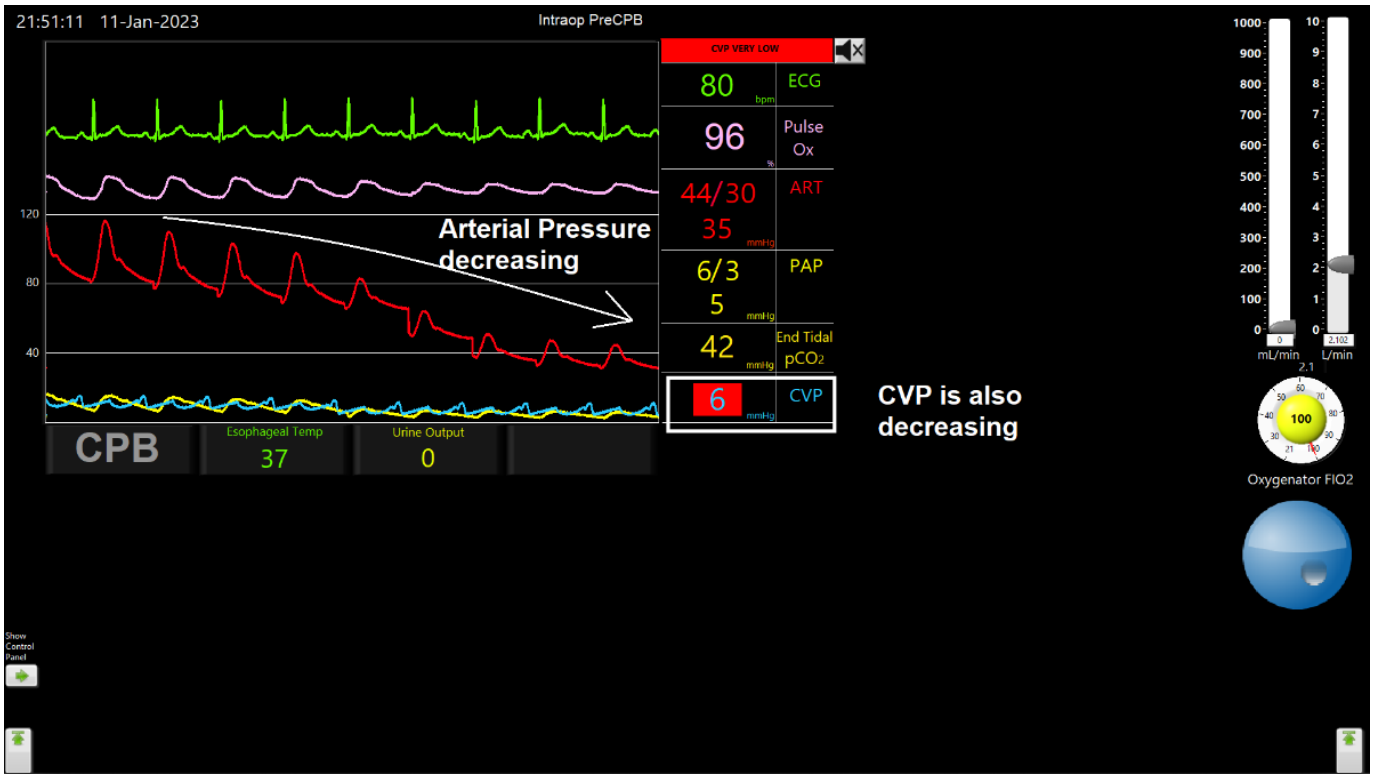

Figure 4.10 Arterial and CVP decreasing

SIM

Prime virtual circuit, refer to Figure 4.11.

Bring up bottom ribbon,

① Press **Fluids Panel** button.

② Press **HLM Controls** button.

In **Fluids Panel,**

③a Select **Crystalloid** from Fluids drop-down menu.

③b Enter ***1000*** *mL* of Volume.

③c Light up the **Priming** button.

③d Press **Apply** button then **Confirm**.

④ Notice **Venous Reservoir** fills up with this priming volume.

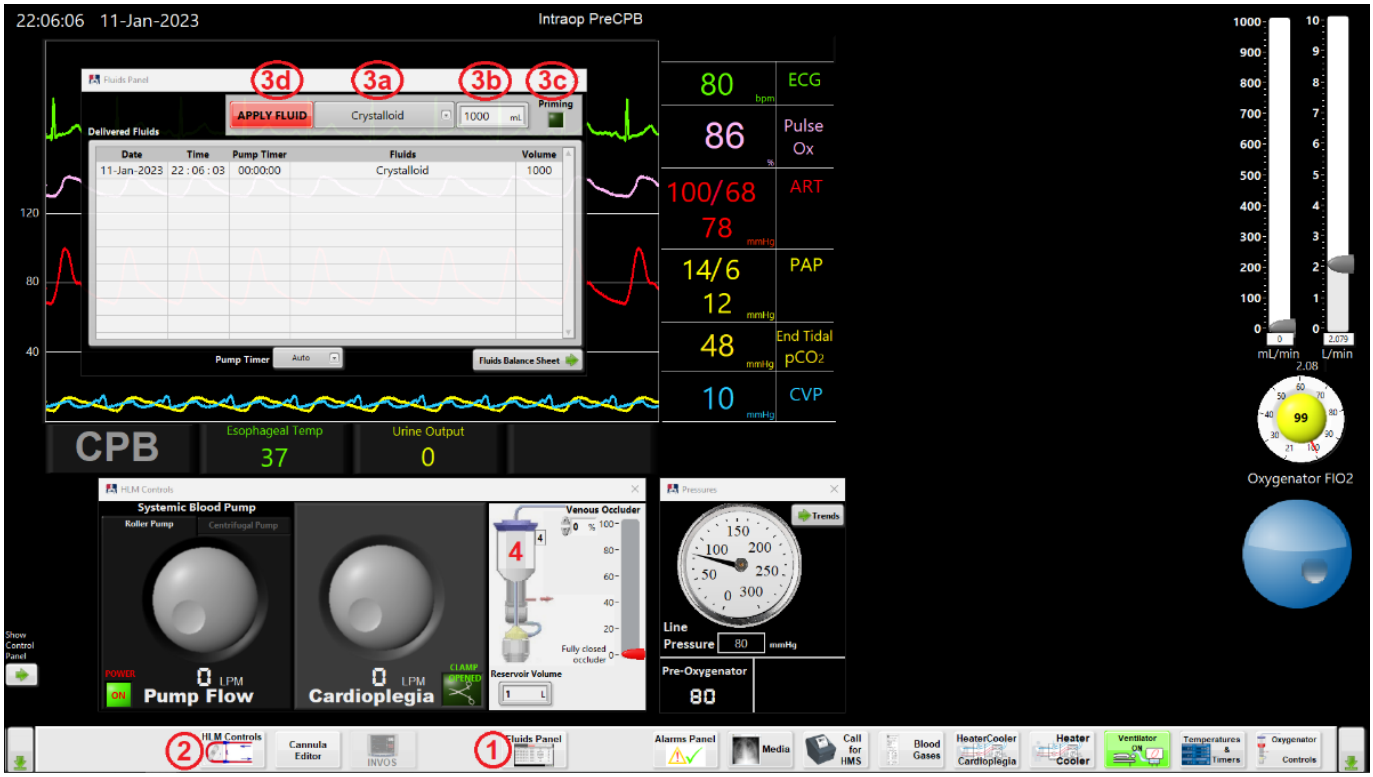

Figure 4.11 Prime circuit using Fluids Panel

CONTINUED…

To go on bypass, refer to Figure 4.12,

① Gradually open **Venous Occluder.**

② Start increasing systemic pump flow.

Virtual systemic pump is a roller pump; hence flow rate is dictated as opposed to speed (RPM).

③ Observe arterial pressure waveform flattening. As flow is increased, mean arterial pressure rises.

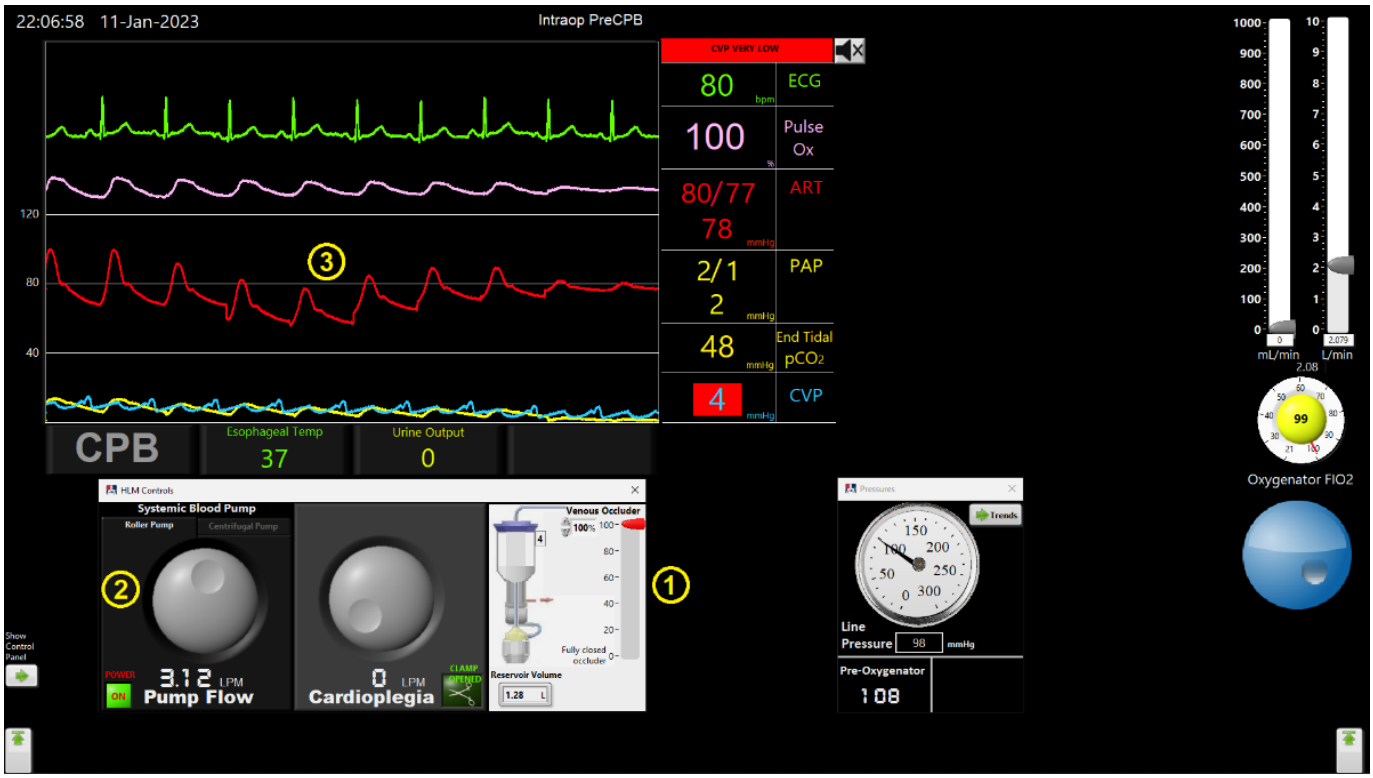

Figure 4.12 Starting bypass (SIM)

4.11 Give Cardioplegia

Refer to Figure 4.13, in **Instructor's Panel » Cardioplegia**,

① Set slider to **Ante** (Antegrade Cardioplegia delivery).

② Close **X Clamp.**

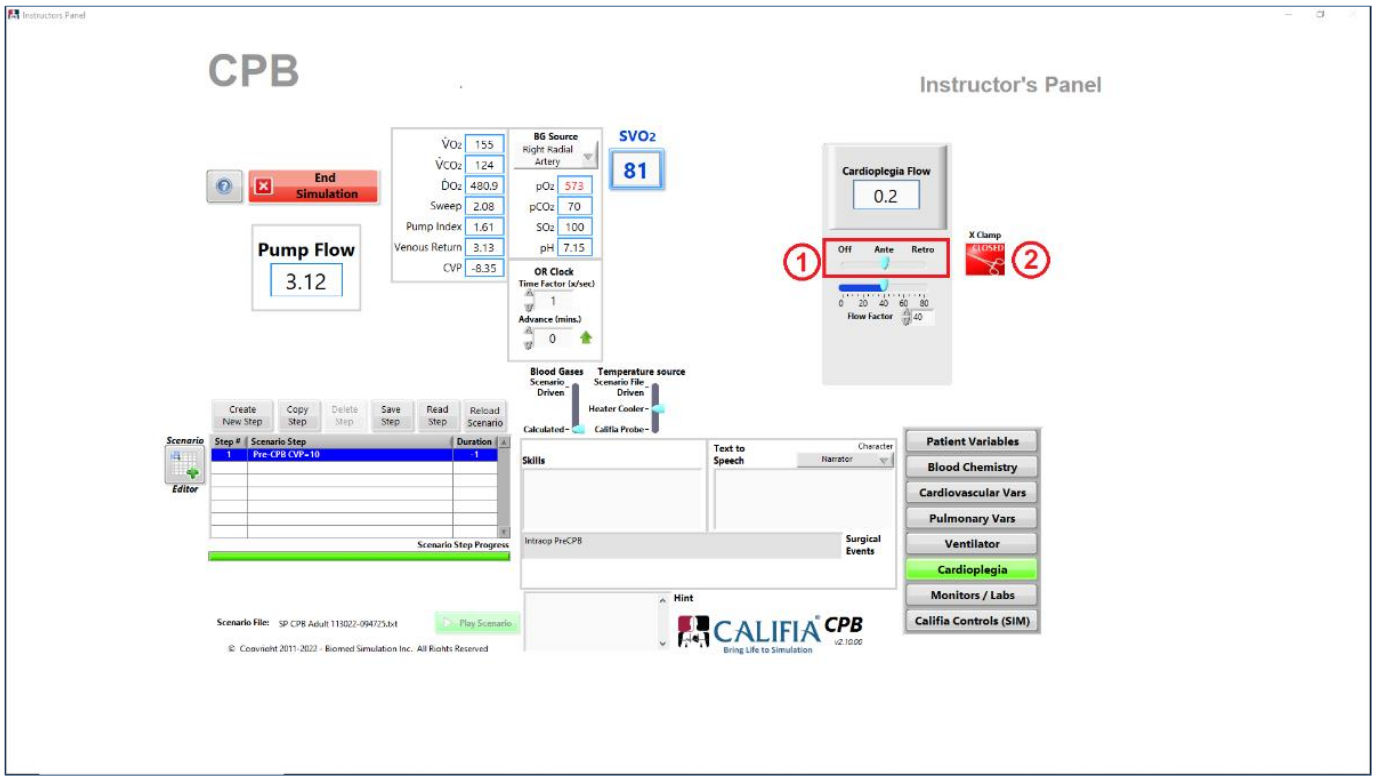

Figure 4.13 Prepare for Cardioplegia delivery

Califia Patient Module

Flow into Cardioplegia port. As flow is registered in the simulation software, the heart ECG will sequence through waveform patterns until the heart is completely arrested, Figure 4.14.

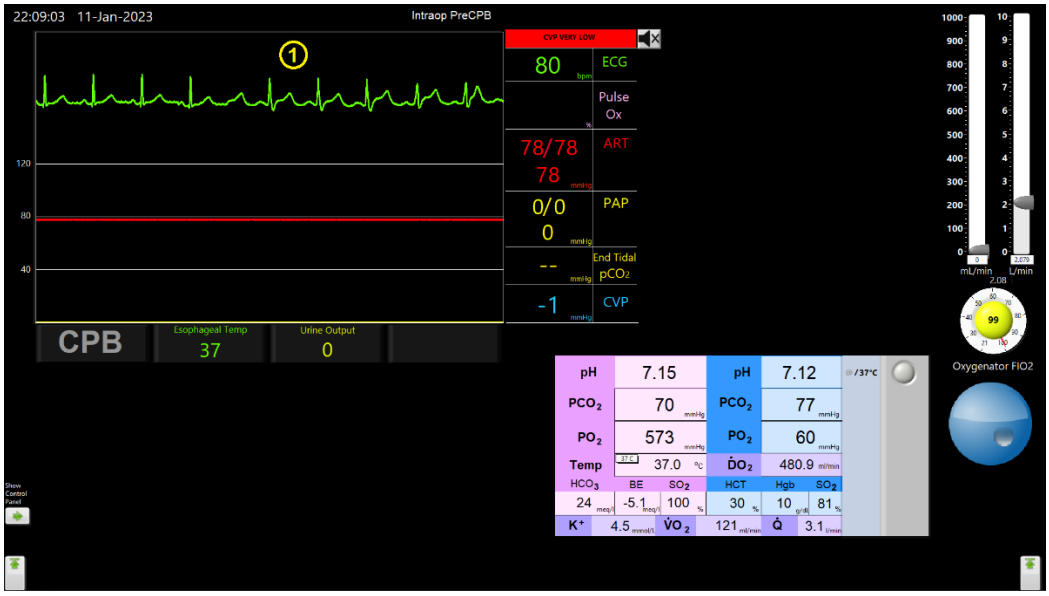

Figure 4.14 Heart ECG under Cardioplegia delivery

SIM

Refer to Figure 4.15:

1. Close **X Clamp** in **HLM Controls** panel.
2. Increase **Cardioplegia** pump flow.
3. Notice **ECG** pattern change.

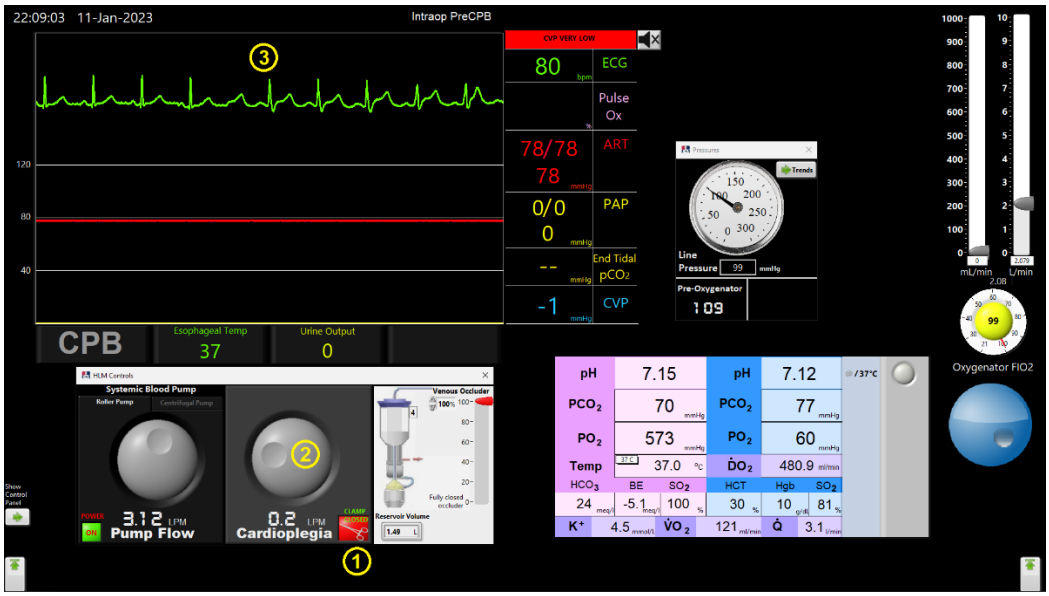

Figure 4.15 Heart ECG under Cardioplegia delivery (SIM)

4.12 Event: Cannula malposition

Refer to Figure 4.16, in **Instructor's Panel » Califia Controls**,

① Set **Delivery Cannula (%)** slider to about ***25%.***

② Arterial line pressure increases.

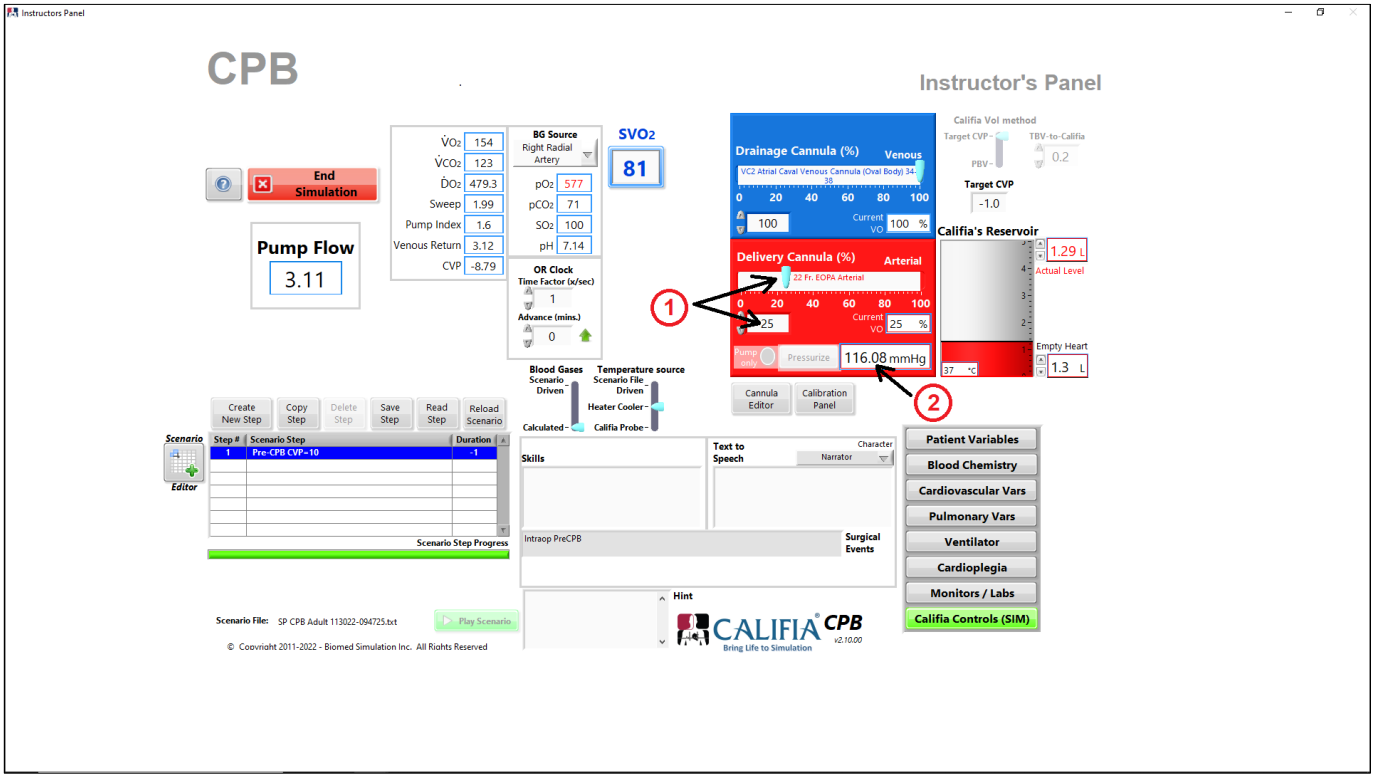

Figure 4.16 Arterial Cannula set to 25% opened

Arterial line pressure should report a high value due to high resistance generated by the smaller arterial valve opening, Figure 4.17.

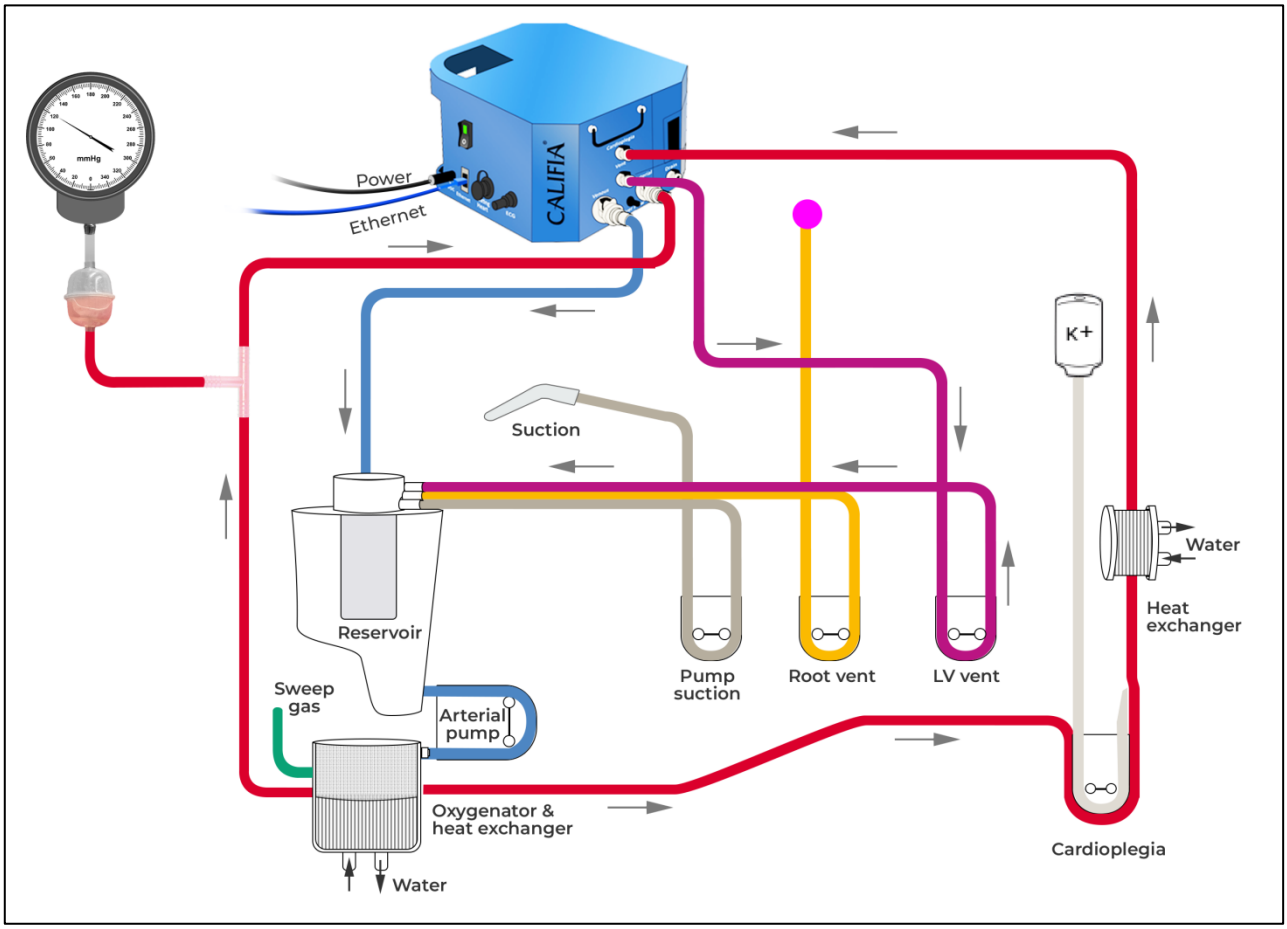

Figure 4.17 High line pressure

Main pump type (Arterial pump)

Roller pump

High line pressure is expected until the pump's speed is lowered.

Centrifugal pump

High line pressure should be experienced momentarily, flow rate decreases and pressure drops somewhat.

SIM

Due to the high resistance generated by the smaller arterial valve opening, the arterial line pressure displayed in the manometer in the **Pressures** panel is very high, Figure 4.18.

Line pressure (post-Oxygenator): *168 mmHg*.

Pre-Oxygenator pressure: *178 mmHg*.

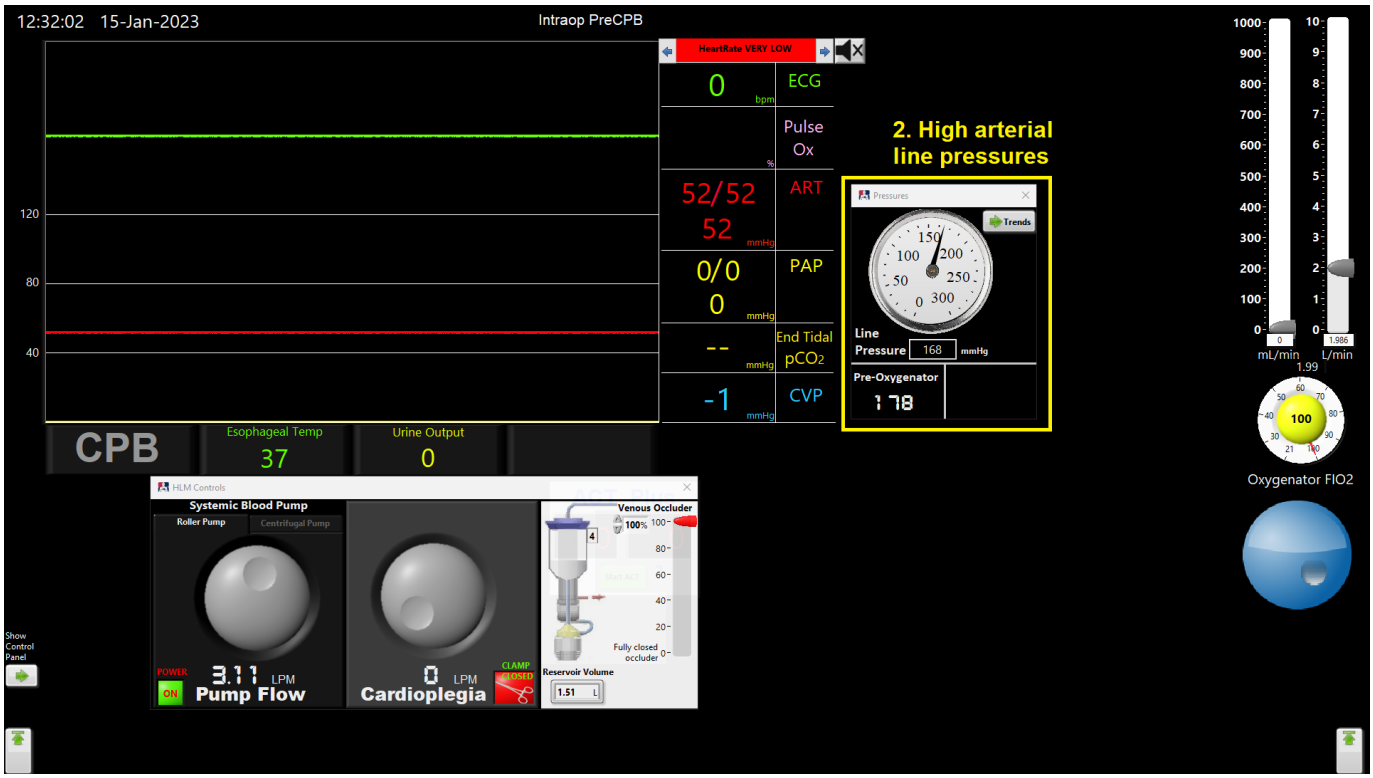

Figure 4.18 High arterial line pressures (SIM)

Set **Delivery Cannula (%)** back to ***100%*** once the event is resolved.

4.13 Remove Cross Clamp

Califia Patient Module

Refer to Figure 4.19,

① Open Cross Clamp in **Instructor's Panel » Cardioplegia.**

② Notice **ECG** pattern return to activity, ending in **SR** (Sinus Rhythm).

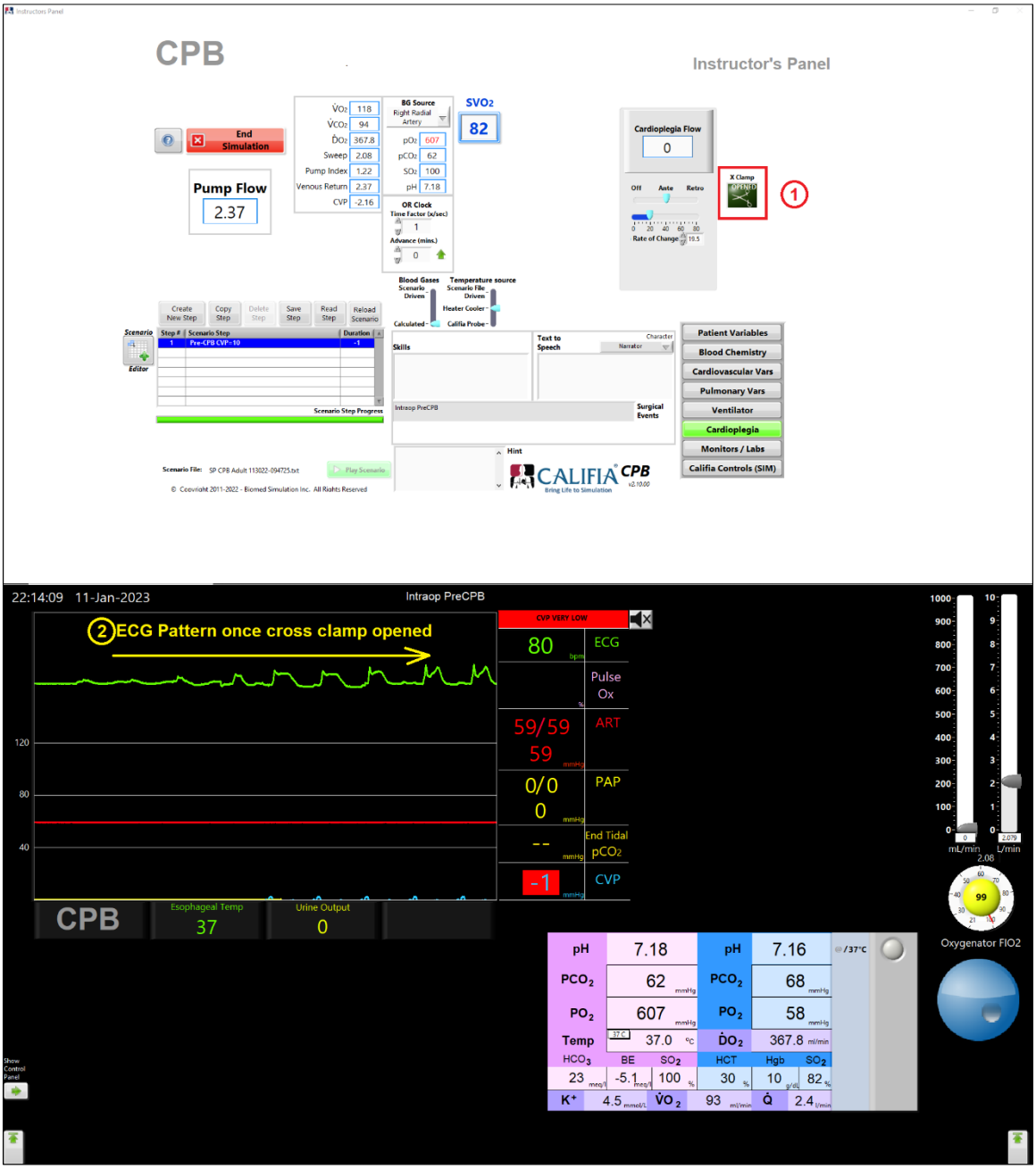

Figure 4.19 Open Cross Clamp

SIM

Refer to Figure 4.20,

1. Open Cross Clamp in **HLM Controls** panel.
2. Notice **ECG** pattern return to activity, ending in **SR**.

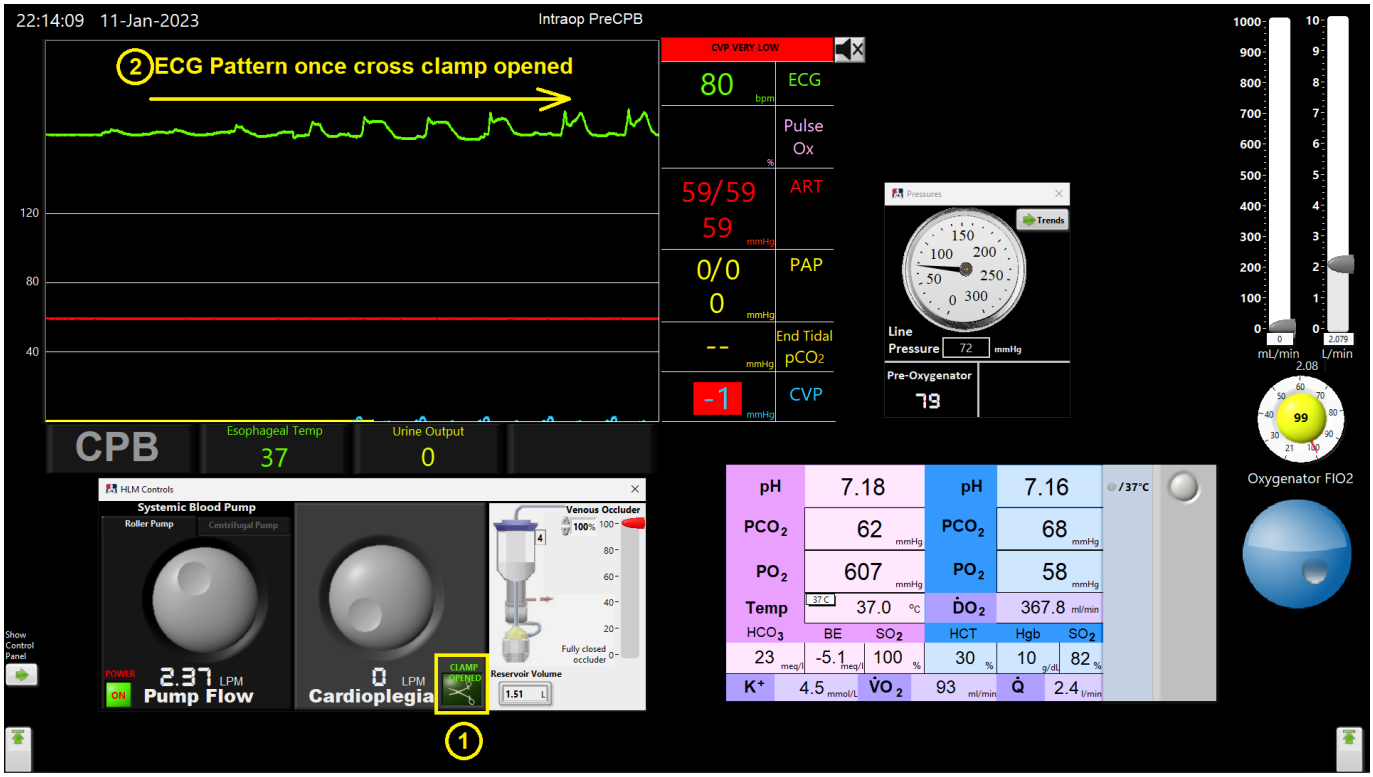

Figure 4.20 Open Cross Clamp (SIM)

4.14 Come off pump!

Califia Patient Module

Refer to Figure 4.21,

Start weaning by partially occluding venous drain and filling patient.

① Notice patient's heart starts to eject and venous pressure increases.

Come-off systemic pump as patient's arterial pressure returns to normal and CVP meets target value.

② Heart has taken over full body perfusion and CVP is normal value.

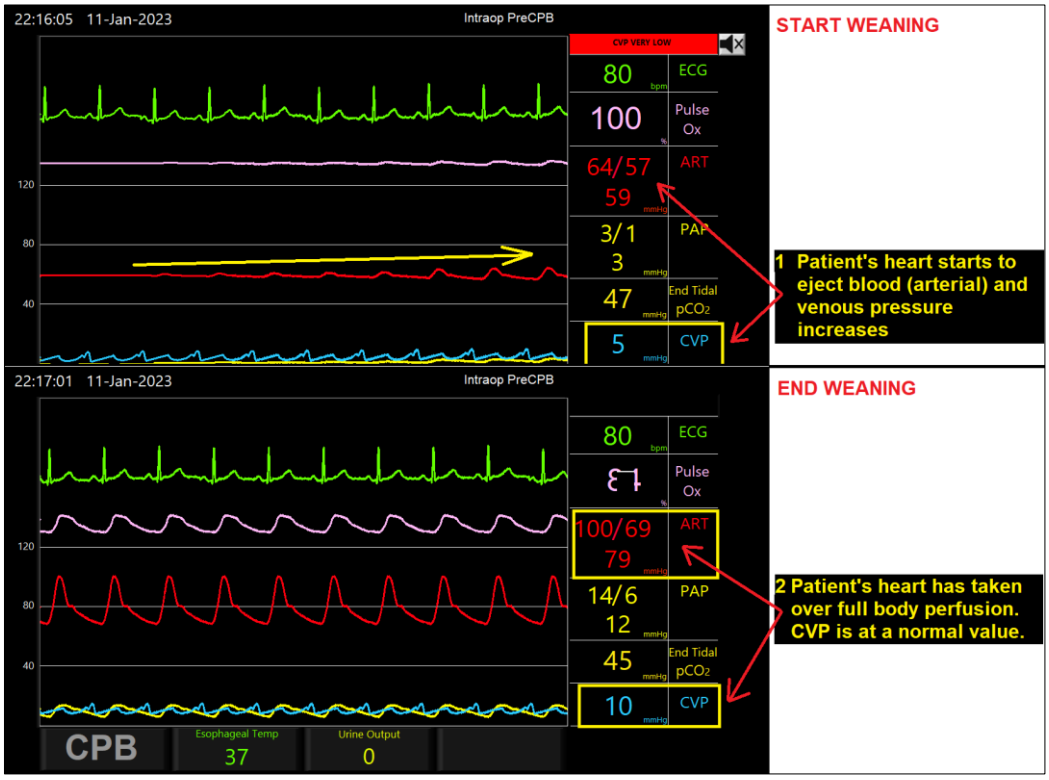

Figure 4.21 Wean off pump

SIM

Refer to Figure 4.22.

① Start weaning by partially occluding venous drain and filling patient.

② Notice patient's heart starts to eject and venous pressure increases.

③ Come-off systemic pump as patient's arterial pressure returns to normal and CVP meets target value.

④ Heart has taken over full body perfusion and CVP is normal value.

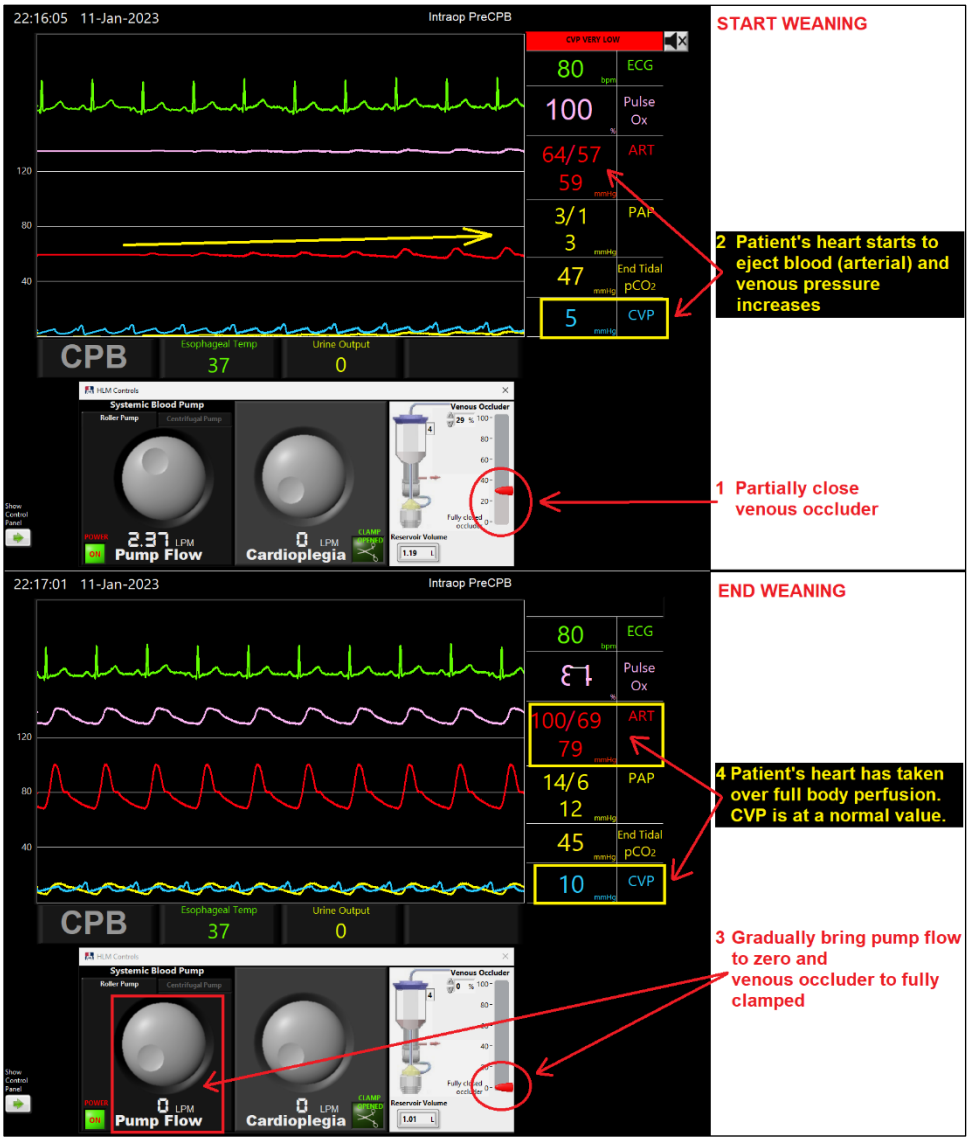

Figure 4.22 Wean off pump (SIM)

4.15 Return to Opening Screen

Refer to Figure 4.23, press **End Simulation** button, ①; confirm request to return to **Opening Screen**, ②.

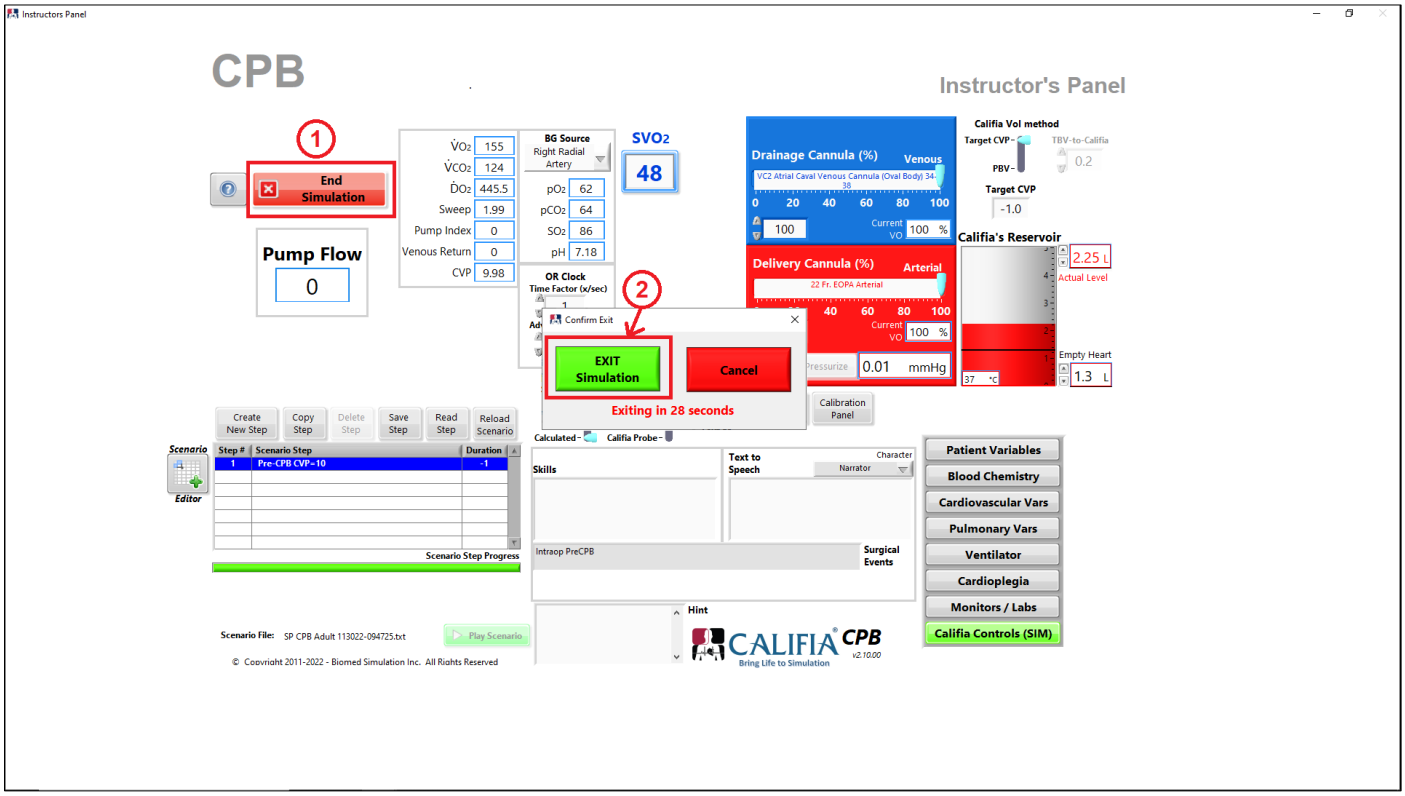

Figure 4.23 End Simulation

4.16 Create a CPB Simulation Scenario File

In this section, we will repeat the CPB case presented in this chapter however we will save all stages into a scenario file.

4.16.1 Access Scenario Editor

Refer to Figure 4.24, Press **MENU** button, ①, followed by **Scenario Editor** button, ②.

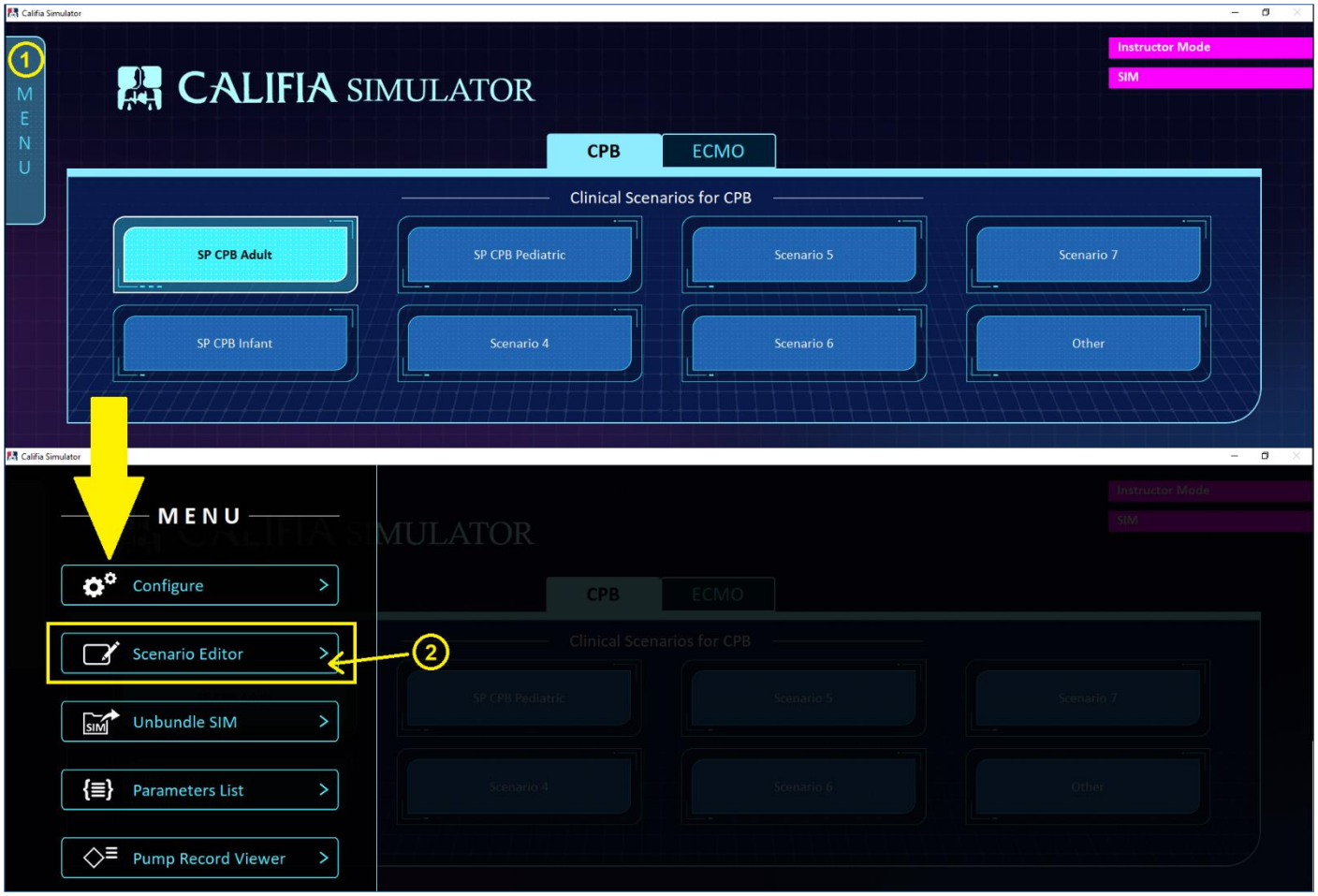

Figure 4.24 Access MENU in Opening Screen then Scenario Editor

4.16.2 Save Scenario File

Refer to Figure 4.25, in **Scenario Editor**,

① Press **File** menu selection

② Select **Save As…**

③ Enter a new scenario file name such as *Getting Started – CPB Scenario*

This name is used to create a folder which will host the scenario file and *ventilator.ini* file.

[Optional] – the **Button Selector** defaults to **Other** however a different button can be programmed to be associated with the new scenario file.

④ Press the **Create** button to complete the new scenario file creation.

Notice the **Scenario Editor** panel title reflects the new folder location and file name.

⑤ Once the new scenario file and folder are created, return to **File** menu and press **Close.**

Press **Close** button to close the **MENU** bar, this step is not shown.

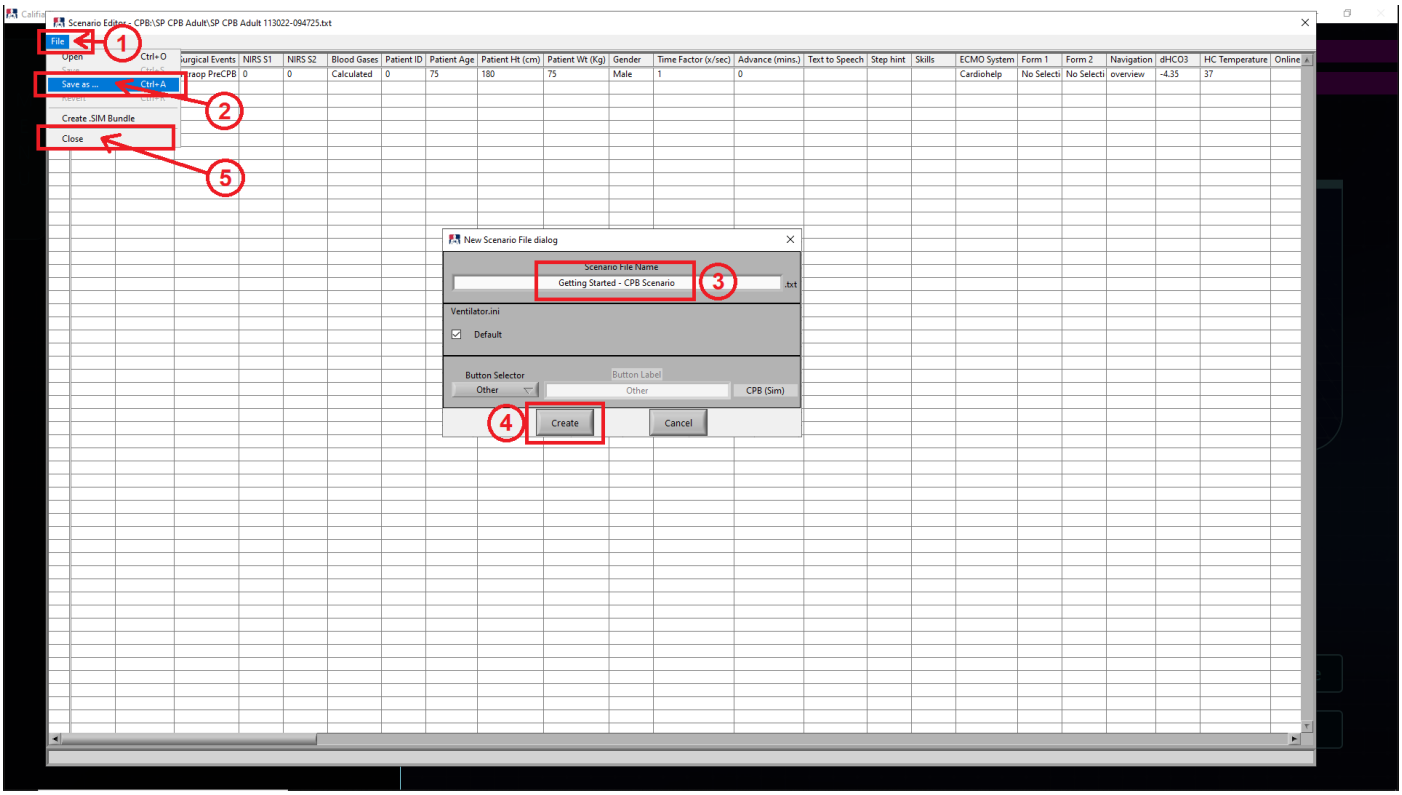

Figure 4.25 Save As... dialog in Scenario Editor

4.16.3 New scenario file in Opening Screen

Refer to Figure 4.26, **Opening Screen,**

① **Location of Scenario File** points to the newly created Scenario File.

② The selected button is **Other** as previously specified in the **Save As…** dialog.

③ Press **Continue** button to load new scenario file.

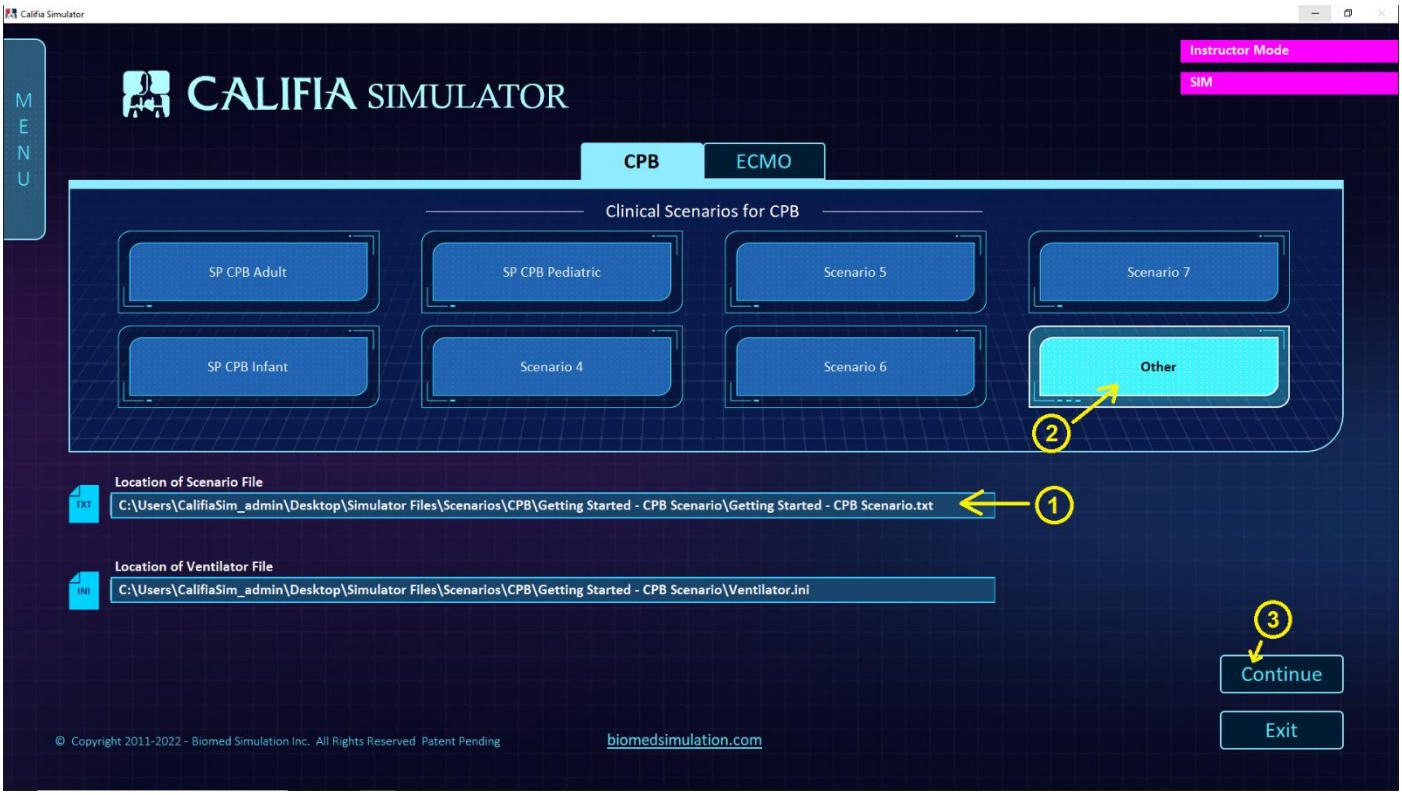

Figure 4.26 Opening Screen - New Scenario File

4.16.4 Scenario File Step 2: Select cannulas

The original scenario file was saved with patient's blood gases configured as desired, refer to Section 4.7.

Next is to select cannulas. Follow these steps in **Instructor's Panel**, refer to Figure 4.27.

① Press **Create New Step**

② Step #2 is added to scenario table; type ***Select cannulas*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

3 Follow steps in Section 4.8 to select cannulas.

④ Press **Save Step**** button.

** refers to the step having been modified and needs to be saved.

⑤ In the **Confirm Scenario File write** dialog, select both **Drainage Cannula** and **Delivery Cannula 1.**

Hold <*Ctrl*> key to select multiple entries.

⑥ Press **Confirm** button to save selected step changes to scenario file.

Original scenario file is not overwritten. A new one is created in the same work folder; its filename includes a timestamp.

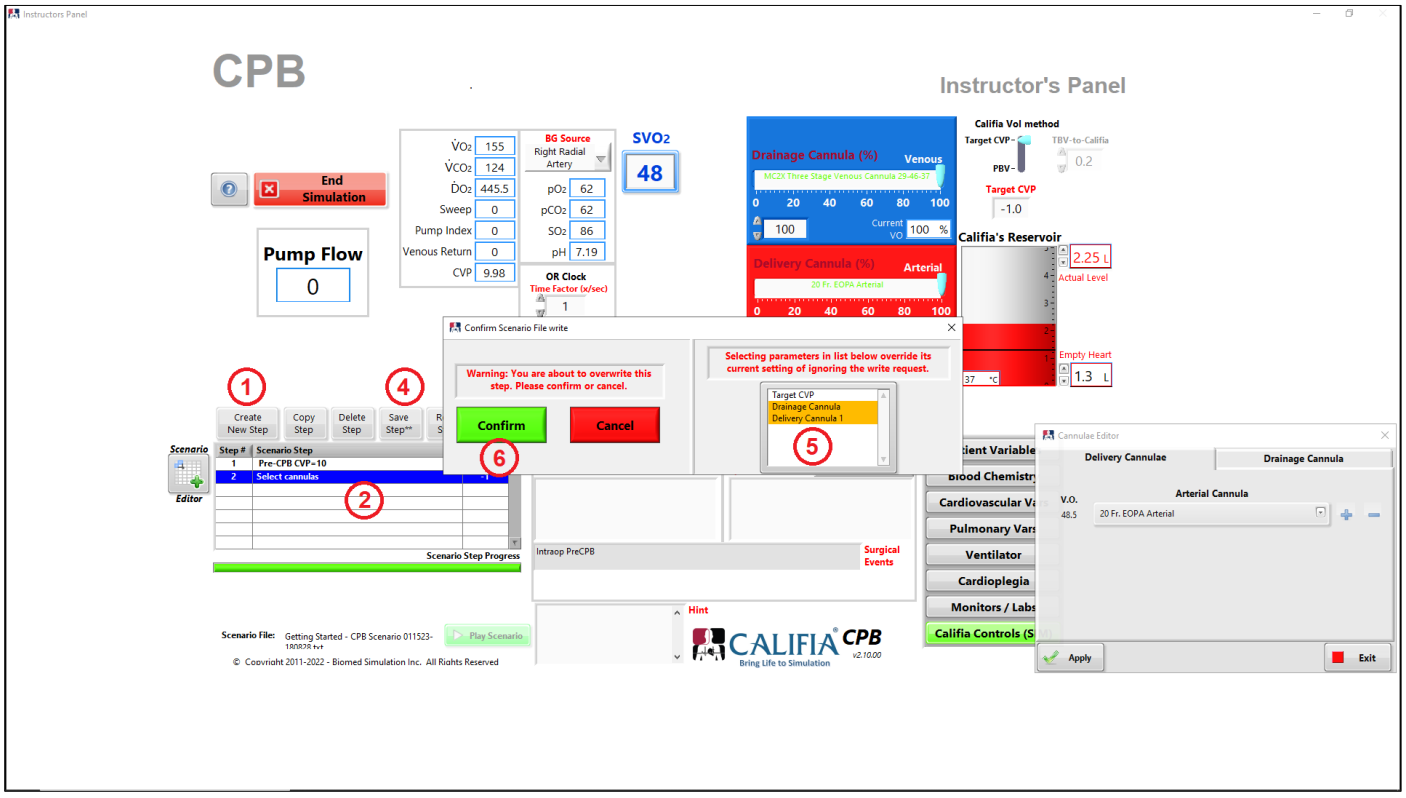

Figure 4.27 Step 2 edits

4.16.5 Scenario File Step 3: Go on pump

Follow these steps, refer to Figure 4.28,

① Press **Create New Step.**

② Type ***Let's go on pump*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following note in **Skills** field: ***Set gas blender and go on pump.***

④ Add following in **Surgical Events**: ***Go on pump.***

This is displayed along the top of the Learner Screen.

5 Follow steps in Section 4.9 to set gas blender and Section 4.10 to go on pump.

⑥ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑦ In the **Confirm Scenario File write** dialog, select both **Skills** and **Surgical Events.**

Hold <*Ctrl*> key to select multiple entries.

⑧ Press **Confirm** button to save step changes to scenario file.

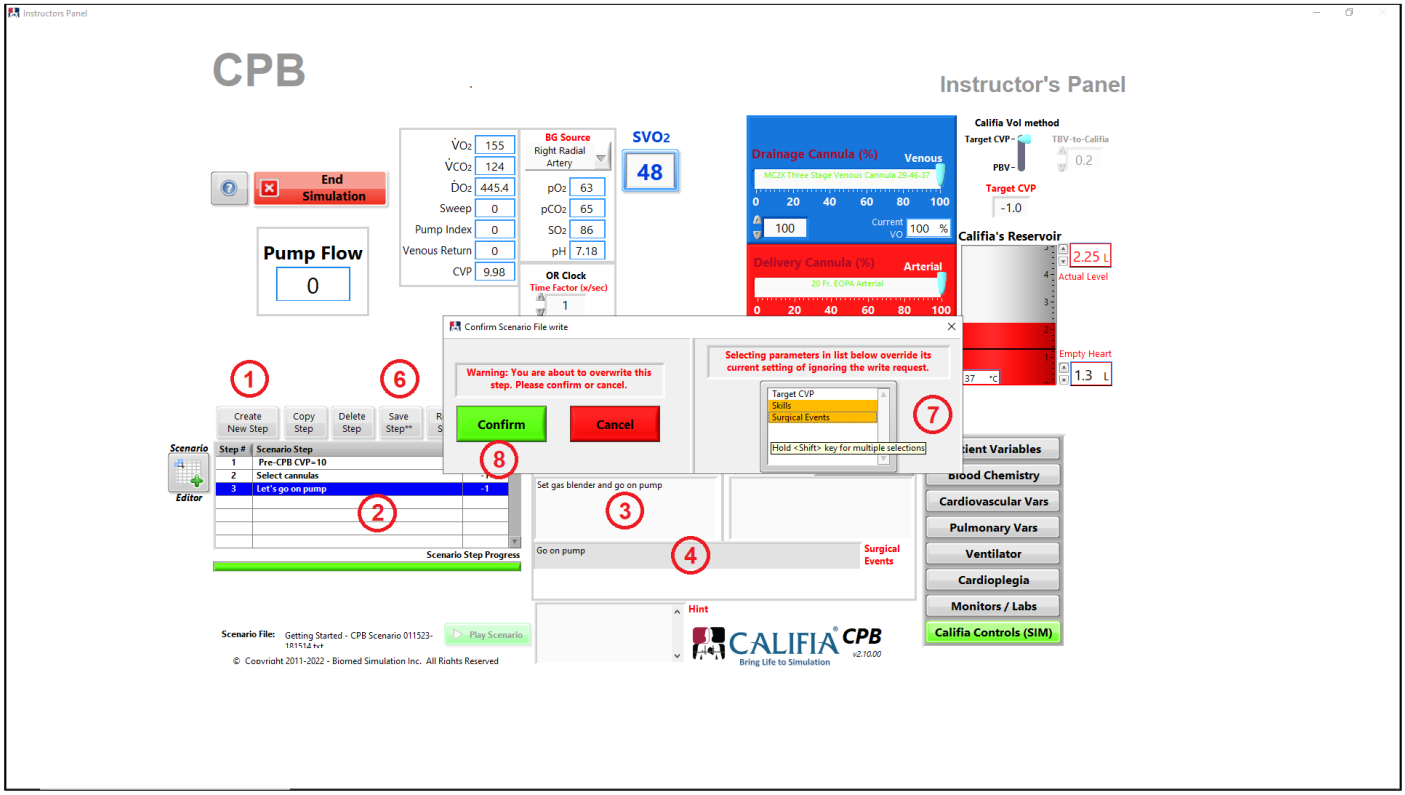

Figure 4.28 Step 3 edits

4.16.6 Scenario File Step 4: Give Cardioplegia

Follow these steps, refer to Figure 4.29,

① Press **Create New Step.**

② Type ***Give Cardioplegia*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Remove existing note in **Skills** field.

④ Add following in **Surgical Events**: ***Give Cardioplegia.***

This is displayed along the top of the Learner Screen.

5 Follow steps in Section 4.11 to deliver cardioplegia.

⑥ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑦ In the **Confirm Scenario File write** dialog, select both **Cross Clamp** and **CP Delivery.**

Hold <*Ctrl*> key to select multiple entries.

⑧ Press **Confirm** button to save step changes to scenario file.

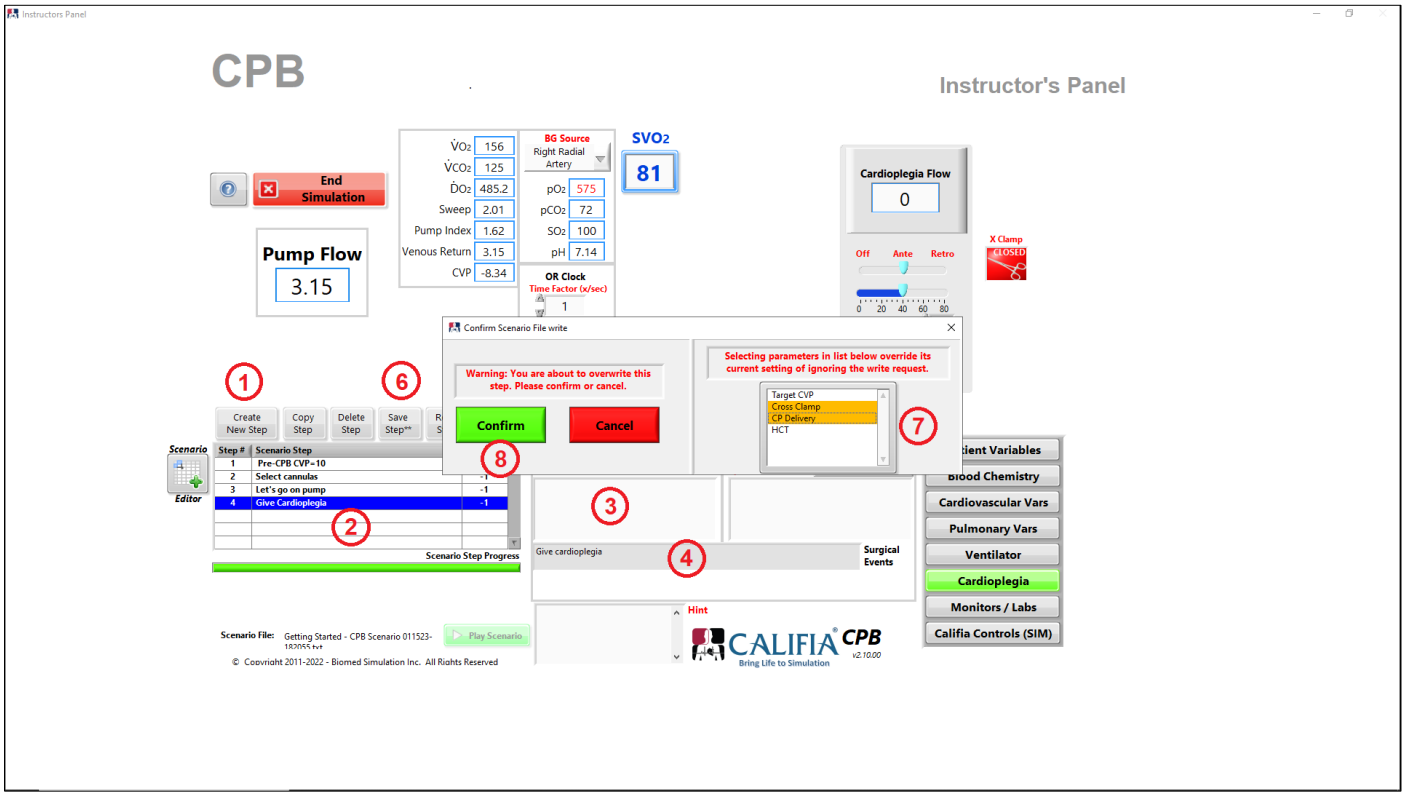

Figure 4.29 Step 4 edits

4.16.7 Scenario File Step 5: Event: Cannula malposition

Follow these steps, refer to Figure 4.30,

① Press **Create New Step.**

② Type ***Event – Cannula malposition*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Remove existing note in **Surgical Events** field.

4 Follow steps in Section 4.12 for Event: Cannula malposition.

⑤ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑥ In the **Confirm Scenario File write** dialog, select both **Delivery Cannula 1 (%)** and **Surgical Events.**

Hold <*Ctrl*> key to select multiple entries.

⑦ Press **Confirm** button to save step changes to scenario file.

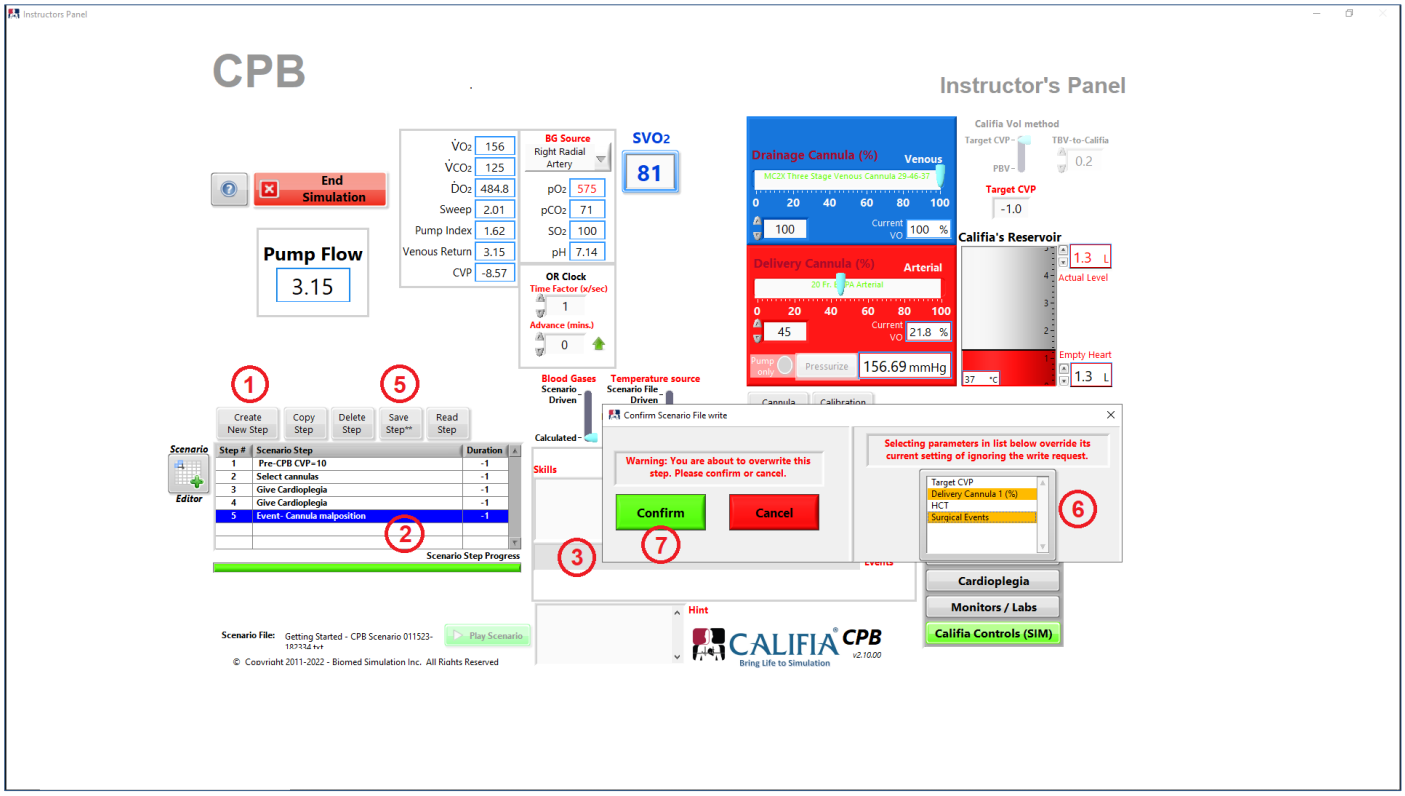

Figure 4.30 Step 5 edits

4.16.8 Scenario File Step 6: Open Cross Clamp

Follow these steps, refer to Figure 4.31,

① Press **Create New Step.**

② Type ***Open Cross Clamp*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following note in **Skills** field: ***Return Delivery Cannula to 100% and open cross clamp.***

4 Follow steps in Section 4.13 to Open Cross Clamp.

Also, set **Delivery Cannula (%)** to ***100%*** since cannula malposition event has been fixed.

⑤ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑥ In the **Confirm Scenario File write** dialog, select **Cross Clamp**, **Delivery Cannula 1 (%)** and **Skills.**

Hold <*Ctrl*> key to select multiple entries.

⑦ Press **Confirm** button to save step changes to scenario file.

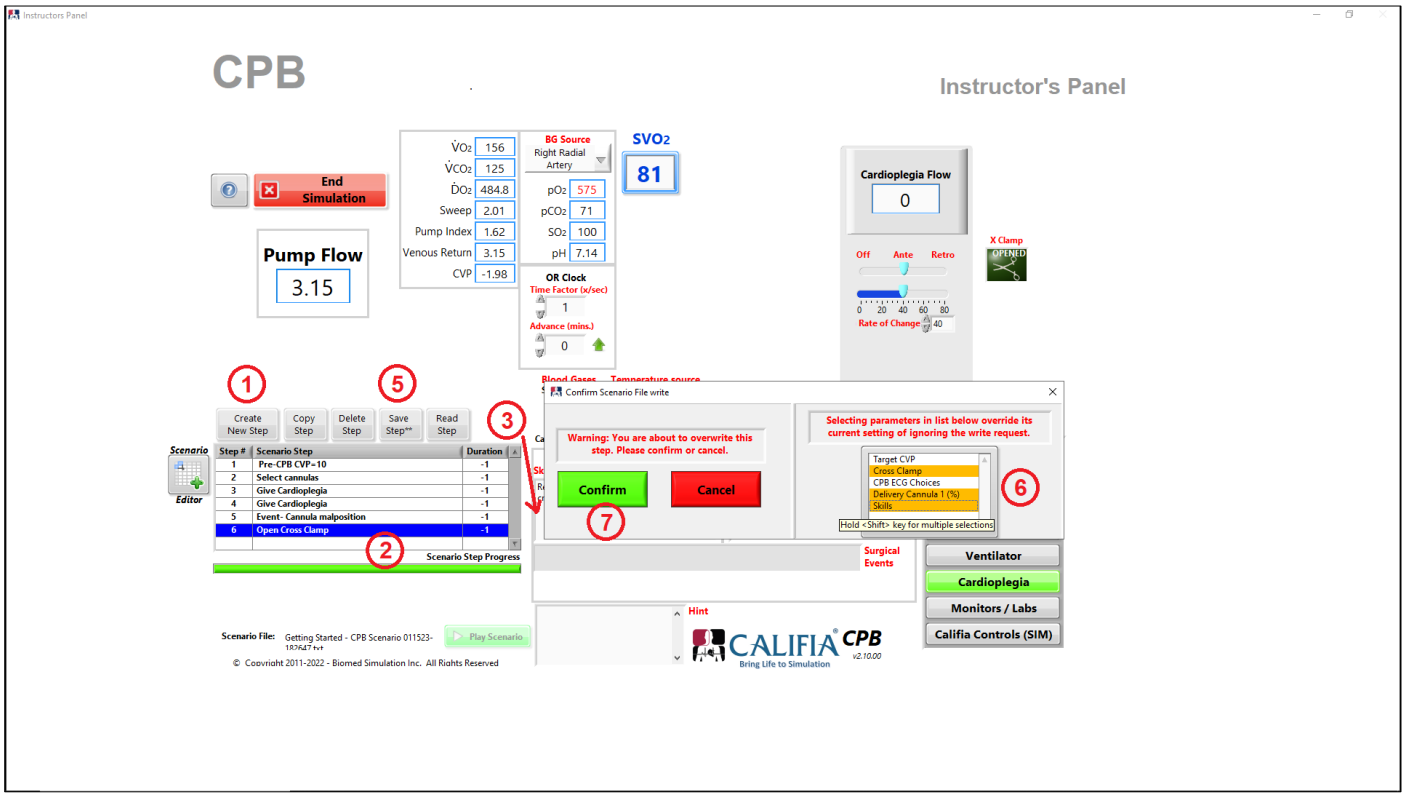

Figure 4.31 Step 6 edits

4.16.9 Scenario File Step 7: Come off pump

Follow these steps, refer to Figure 4.32,

① Press **Create New Step.**

② Type ***Come off pump*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Remove existing note in **Skills** field.

4 Follow steps in Section 4.14 to come off pump.

⑤ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑥ In the **Confirm Scenario File write** dialog, select **Skills.**

Hold <*Ctrl*> key to select multiple entries.

⑦ Press **Confirm** button to save step changes to scenario file.

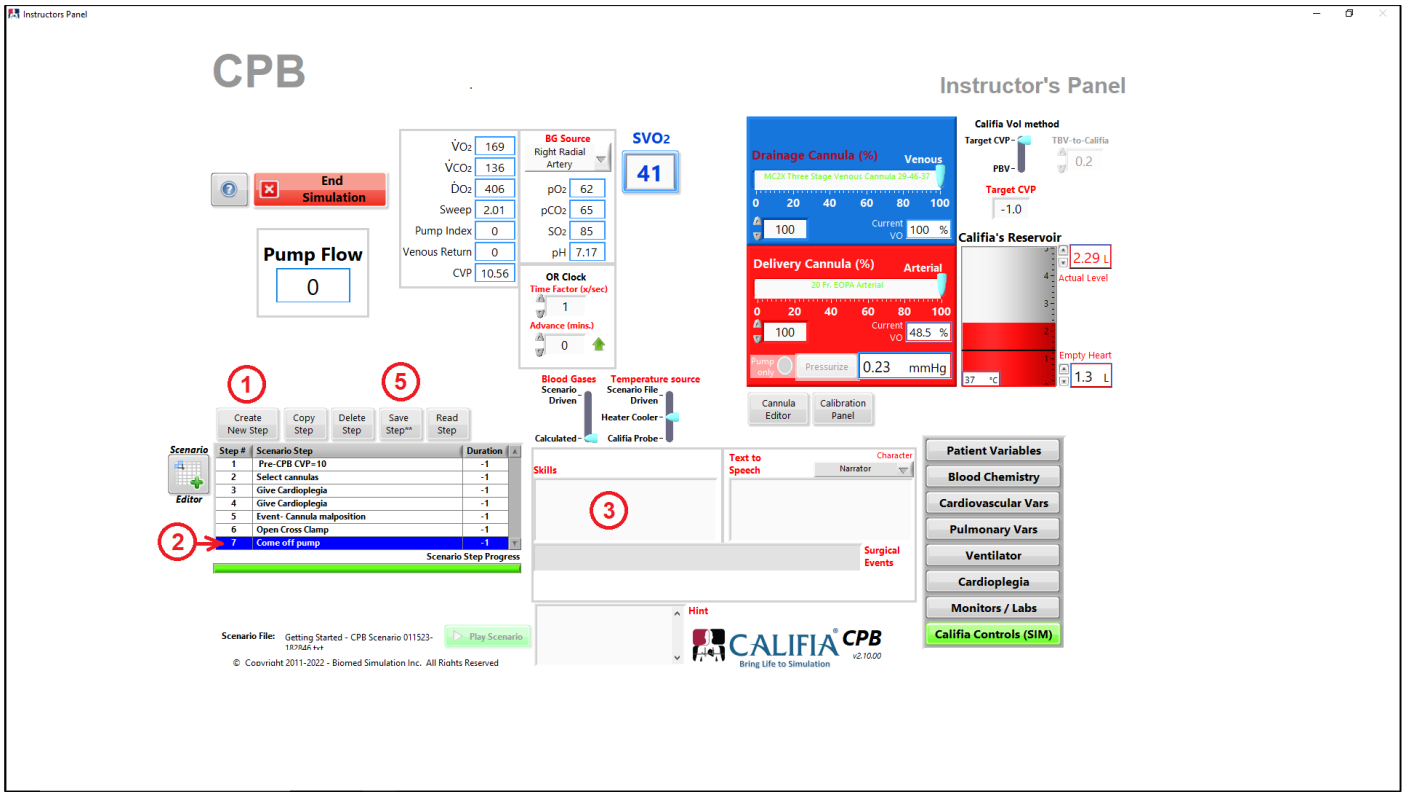

Figure 4.32 Step 7 edits

4.16.10 Run newly created scenario file

Follow these steps, refer to Figure 4.33,

① Press Step 1.

② Press **Read Step** to read first step in scenario file.

③ Use the **Play Scenario** button to play through the scenario file one step at a time.

Table 4.2 outlines the key actions by each player for each step: *Instructor* and *Student*.

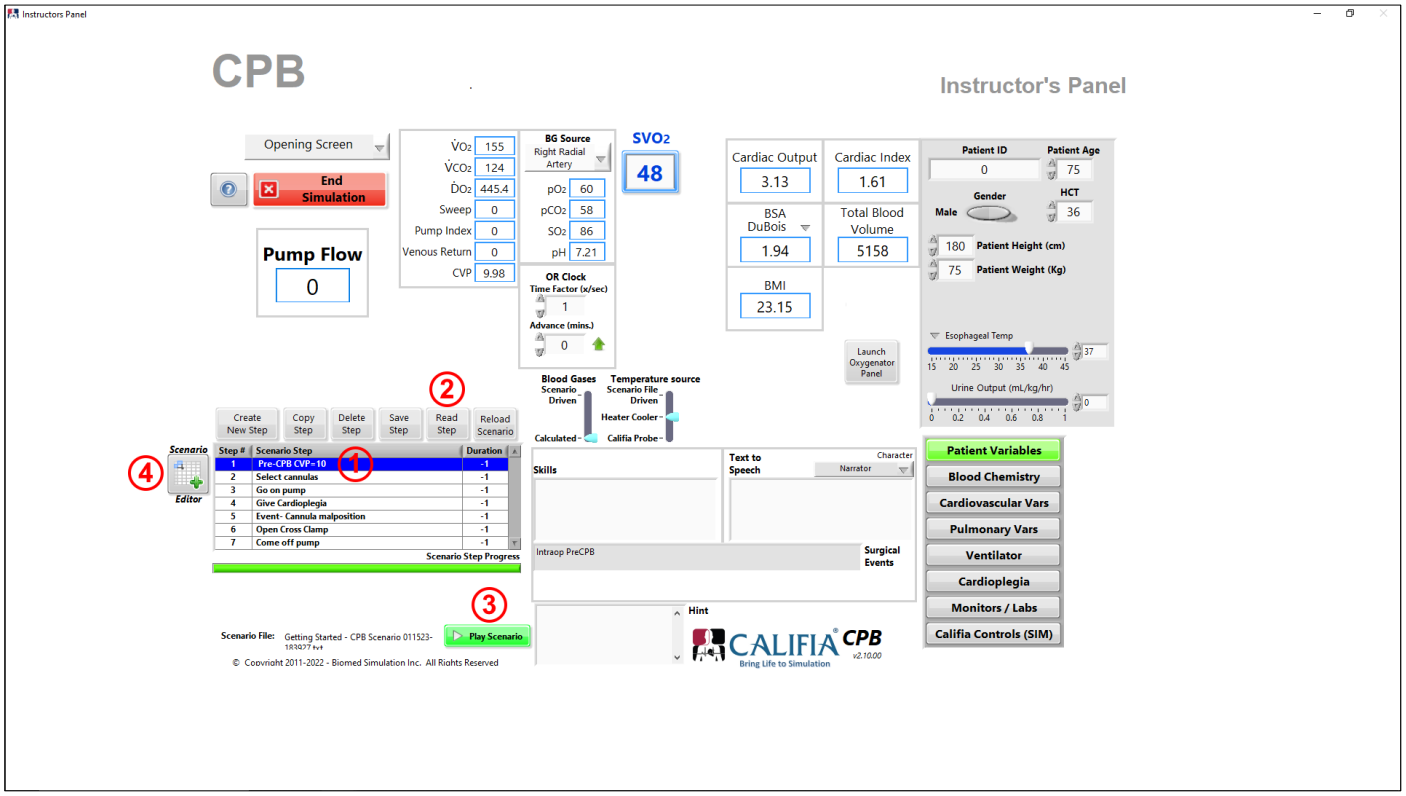

Figure 4.33 Run Scenario File

Step	Instructor	Student
1. Pre-CPB	*Review patient condition*	
2. Select Cannulas	*Review cannula selection*	
3. Go on pump	*Observe*	*Set gas blender, go on pump*
4. Give Cardioplegia	*Close Cross Clamp*	*Deliver CP*
5. Event: Cannula issue	*Observe*	*Identify issue*
6. Open Cross Clamp	*Open Cross Clamp*	*Observe patient vitals*
7. Come off pump	*Observe*	*Wean off pump*

Table 4.2 Actions by Instructor and Student when running this simulation scenario

4.16.11 Package scenario file as a SIM file

A SIM file is a convenient method to package simulation cases. These can be shared and loaded in other computers running the Califia Simulator application.

A single file bundles the following files used in a simulation case:

1. Scenario file.
2. Ventilator.INI file.
3. Any media the scenario uses.
4. Any Lab Reports and TEG images.
5. Future files such as Drug definition files, additional forms (patient condition, history, etc) will be included.

To create a SIM file,

Press **Scenario Editor** button, ④, refer to Figure 4.33.

For the following steps, refer to Figure 4.34,

① Press **File** » **Create .SIM bundle.**

② Choose a target location for the SIM file; shown is the *Desktop*.

③ Press **Create** button to build SIM file.

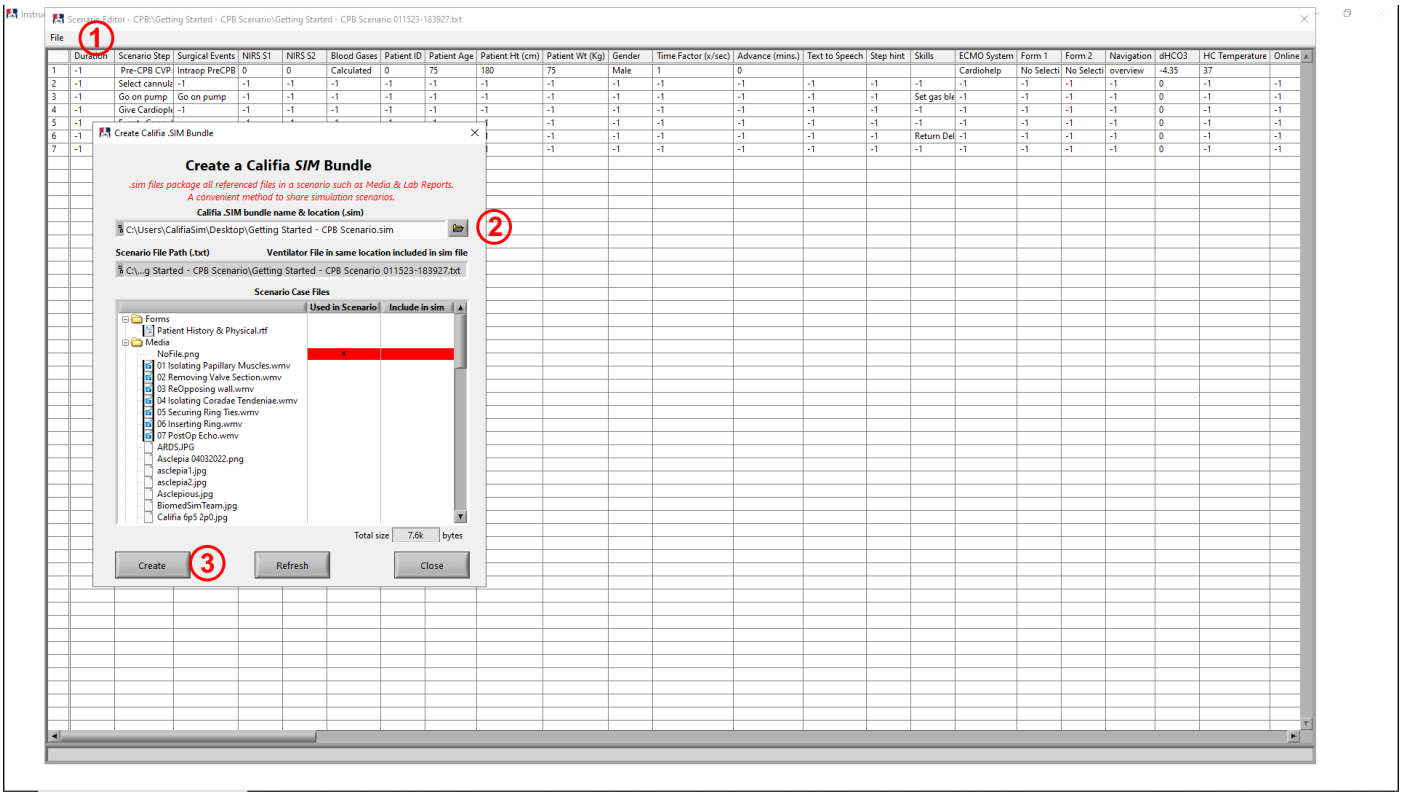

Figure 4.34 Create a SIM bundle

4.16.12 Steps to unbundle a SIM file

To unbundle a SIM file, refer to Figure 4.35,

① From Opening Screen, press **MENU** button then **Unbundle SIM** button.

② Select SIM file.

③ Press **Unbundle** button then **Close** to return to Opening Screen.

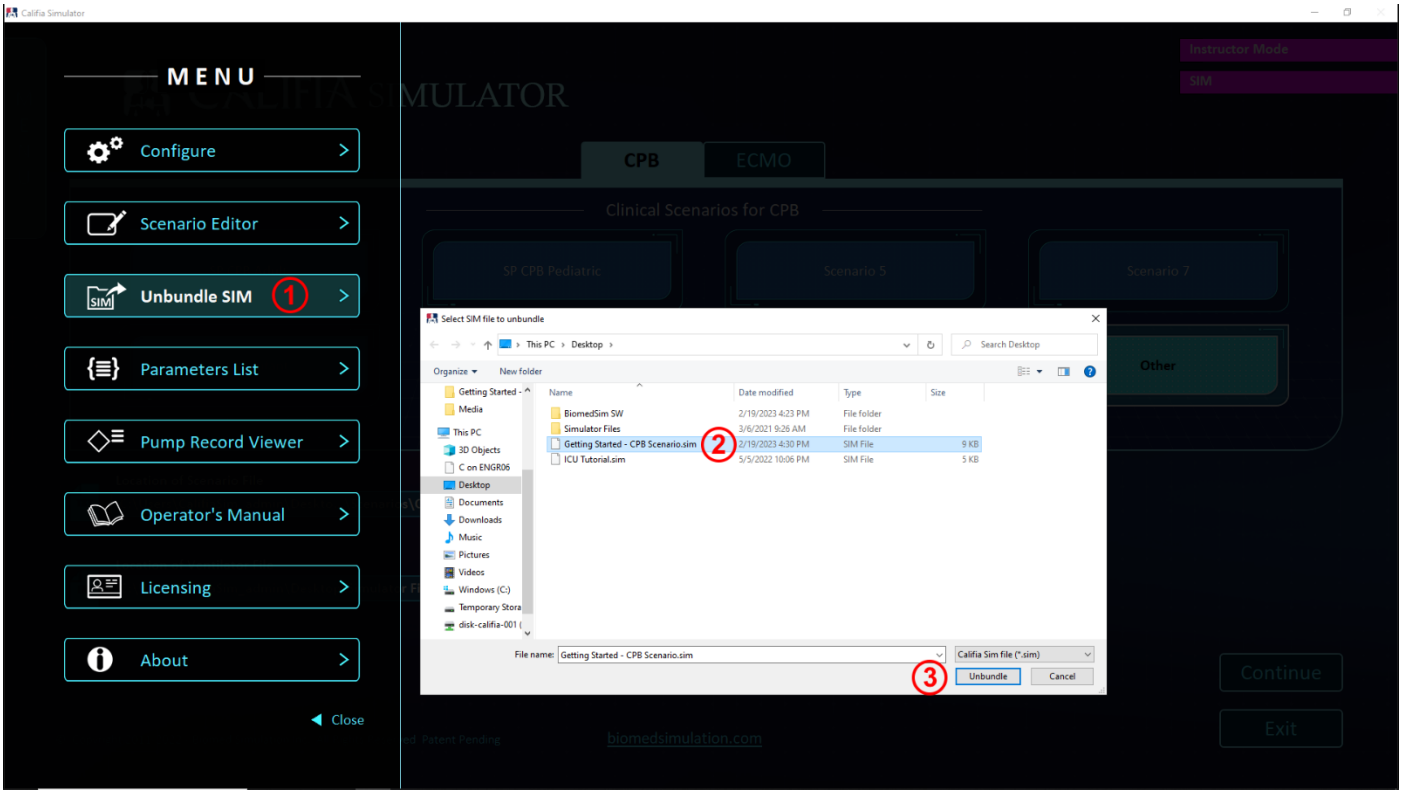

Figure 4.35 Unbundle a SIM file

When a SIM file is unbundled, in addition to placing all files in their proper locations, it configures the Califia Simulator application so it's ready to run the unbundled simulation scenario, refer to Figure 4.36.

① Scenario file and Ventilator.ini file paths are loaded.

② **Other** button is linked with scenario as defined in SIM bundle.

③ The simulation mode (**CPB** or **ECMO**) is selected.

④ The operator can press the **Continue** button to step into the simulation case.

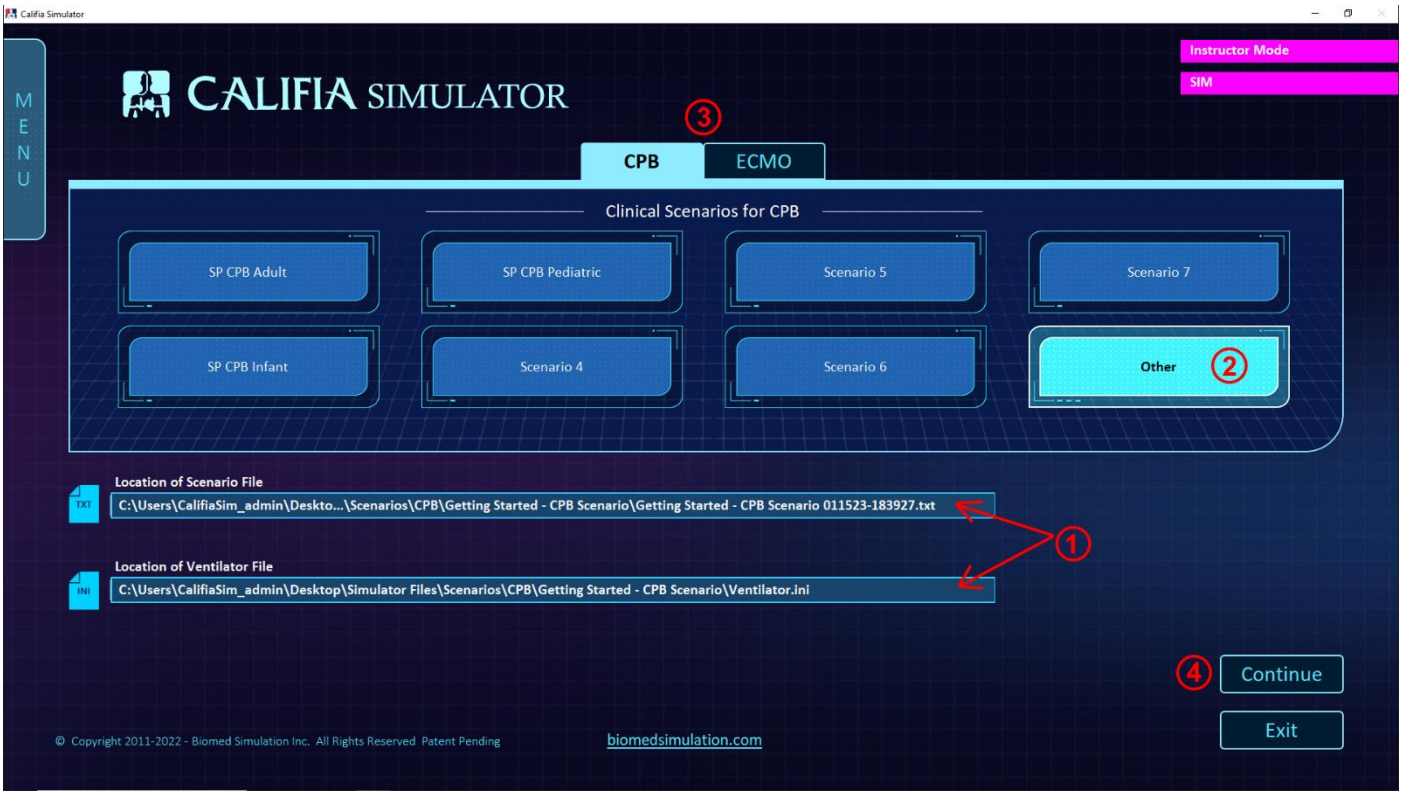

Figure 4.36 Results of unbundling SIM file

5

Let’s go on ECMO! – an ECMO simulation [CPM mode]

This chapter steps through a ECMO simulation. You can follow along.

Approximately 60 minutes to complete this chapter.

5.1 SIM vs Califia Patient Module

Refer to Figure 5.1, ①.

Califia Patient Module	This chapter requires the use of the CPM connected to an ECMO Pump system.

Chapter 6 introduces an ECMO simulation case in SIM mode, no CPM or real pump involved.

5.2 Use a Standardized Patient scenario

Select one of the six SP ECMO scenarios available, Figure 5.1 ②:

- SP VA ECMO Adult
- SP VA ECMO Infant
- SP VA ECMO Pediatric
- SP VV ECMO Adult
- SP VV ECMO Infant
- SP VV ECMO Pediatric

Press **Continue** button**,** ③**,** to step into the simulation.

Figure 5.1 Opening Screen » ECMO mode

5.3 ECMO – Instructor's Panel, Legacy Learner & 3D ICU

The Califia ECMO Simulation environment includes 3 main panels, refer to Figure 5.2. Minimize the **Califia3D ICU** window to show the Legacy Learner screen.

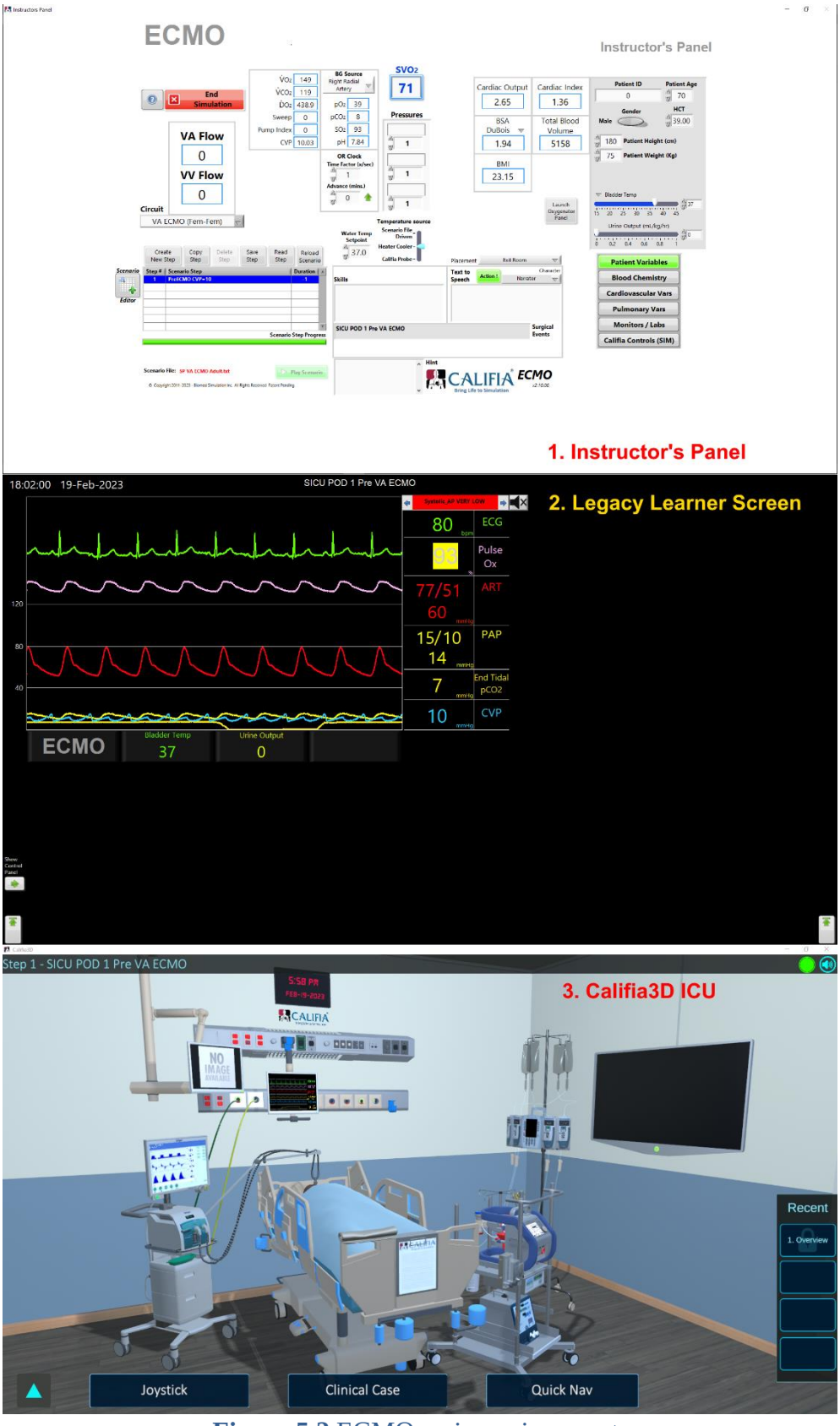

Figure 5.2 ECMO main environments

5.4 Patient Demographics

Refer to Figure 5.3 review and change the following:

① **Age**

② **HCT**

③ **Gender**

④ **Weight**

⑤ **Height**

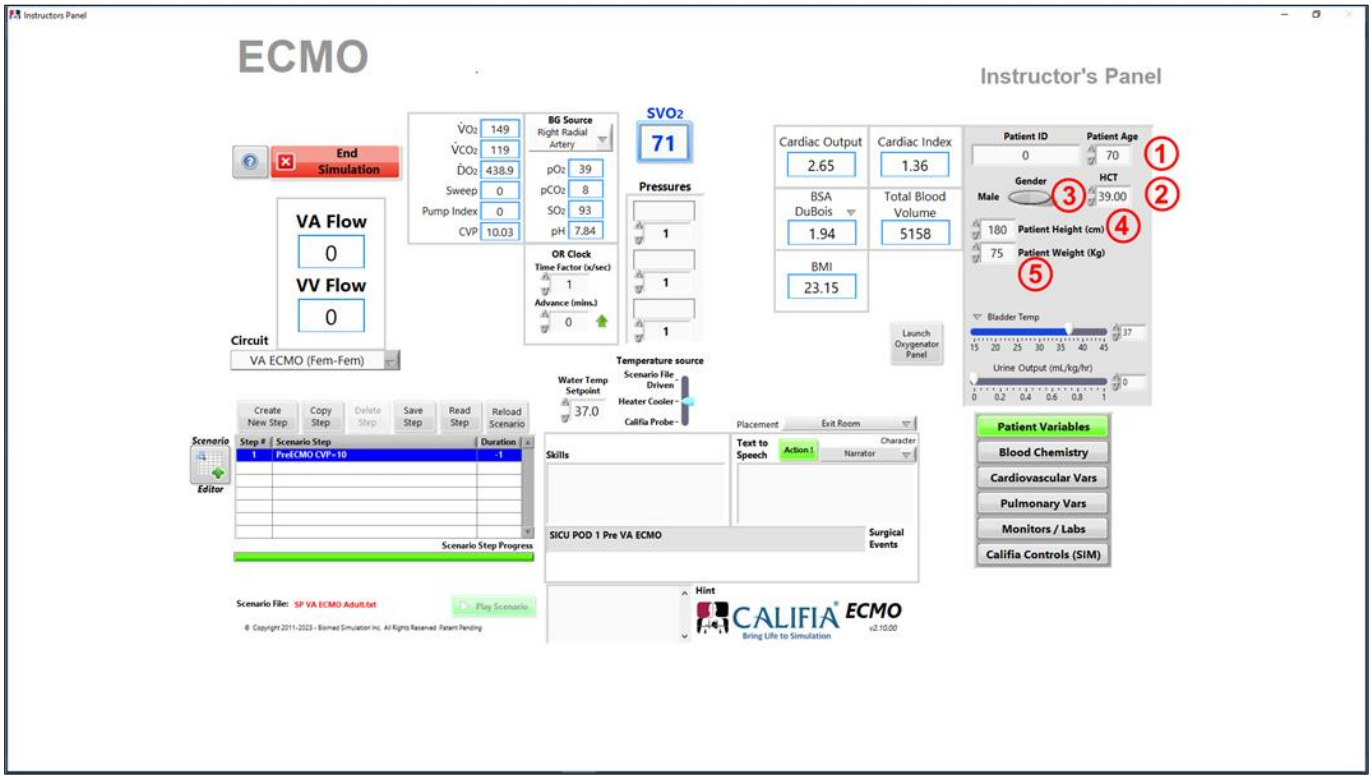

Figure 5.3 Patient demographics in Instructor's Panel

5.5 CVP Gain

In **Instructor's Panel,** press the **Calibration Panel** button under **Califia Controls** to bring up the **Califia Calibration Panel**, Figure 5.4. Set **CVP Gain** as dictated in Table 5.4

BSA (m^2)	CVP Gain
< 1	3.5
Between 1 & 2	3.0
> 2	2.5

Table 5.4 BSA vs CVP Gain

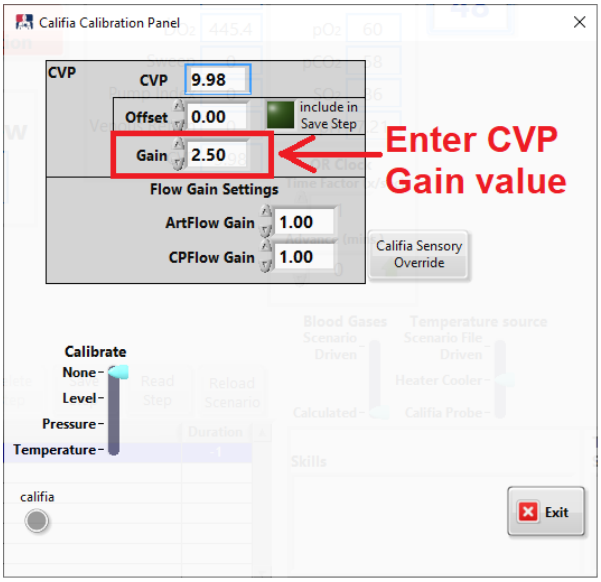

Figure 5.4 Califia Calibration Panel » CVP Gain

5.6 CVP

Set CVP to 10 mmHg

Califia Patient Module

Fill **Califia's Reservoir** until **CVP** is **10** *mmHg*, ① in Figure 5.5.

It's acceptable if the CVP is ± 0.20 of 10 mmHg.

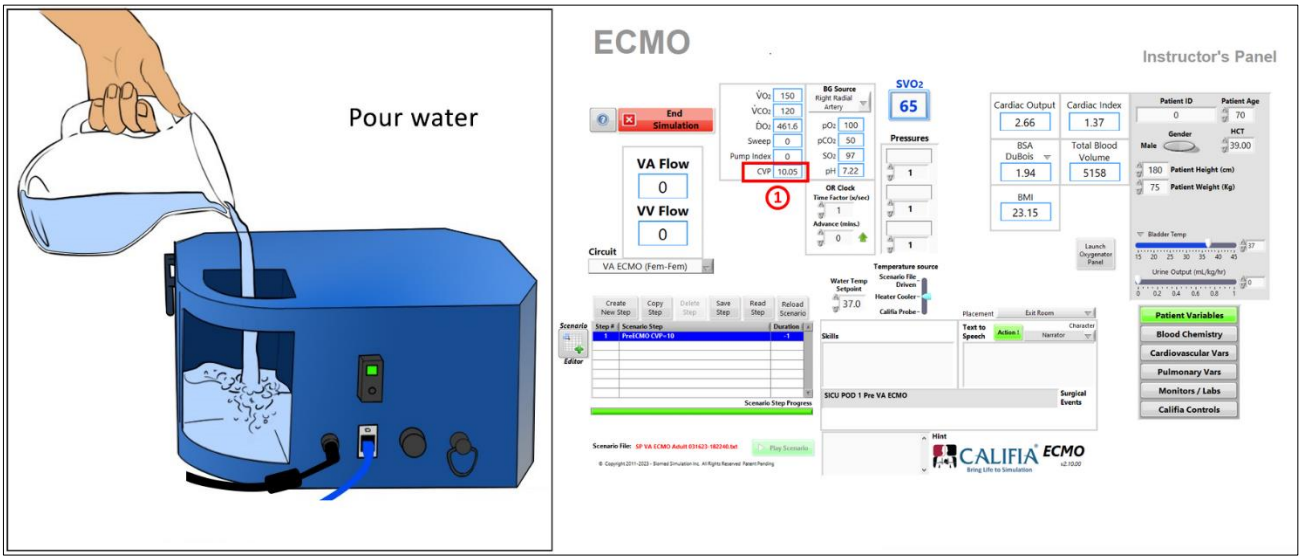

Figure 5.5 Fill CPM with water to match target CVP

5.7 Arterial Pressure

Refer to Figure 5.6, in **Instructor's Panel** » **Cardiovascular Vars**,

① Press **Set Arterial Pressure** button.

② Specify desired **Systolic** and **Diastolic** Arterial Pressures.

③ Press **Target** button.

④ It takes a few seconds to find values for **LV Contractility** and **SVR**.

⑤ Once Targetting is complete, press **Save Step** to save all changes to scenario file.

Close **Model Settings** panel upon saving changes to scenario file.

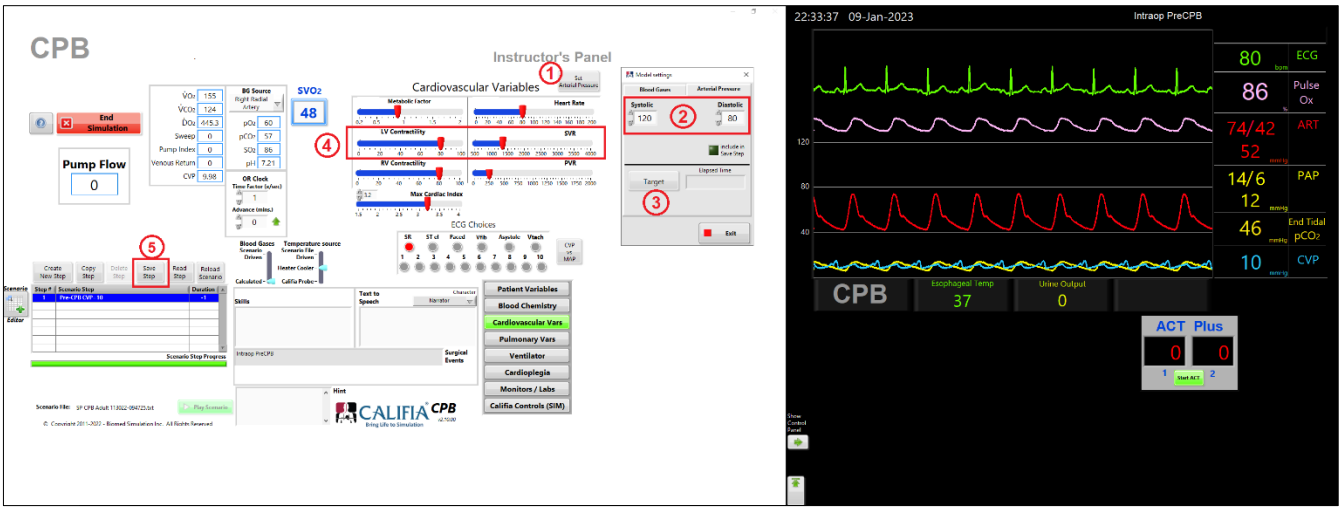

Figure 5.6 Set Systolic and Diastolic Arterial Pressure

5.8 Blood Gases

Refer to Figure 5.7, in **Instructor's Panel** » **Blood Chemistry**.

① Press **Calculate Desired Gases** button.

② Specify desired **pO2**, **pCO2** and **pH** for arterial blood.

③ Press **Target** button.

④ It takes several minutes to find values for **HCO3-**, **Dead Space** and **Pulmonary Shunt Fraction**.

The last two parameters are in the **Pulmonary Vars** section.

⑤ Once Targetting is complete, press **Save Step** to save all changes to scenario file.

Close **Model Settings** panel upon saving changes to scenario file.

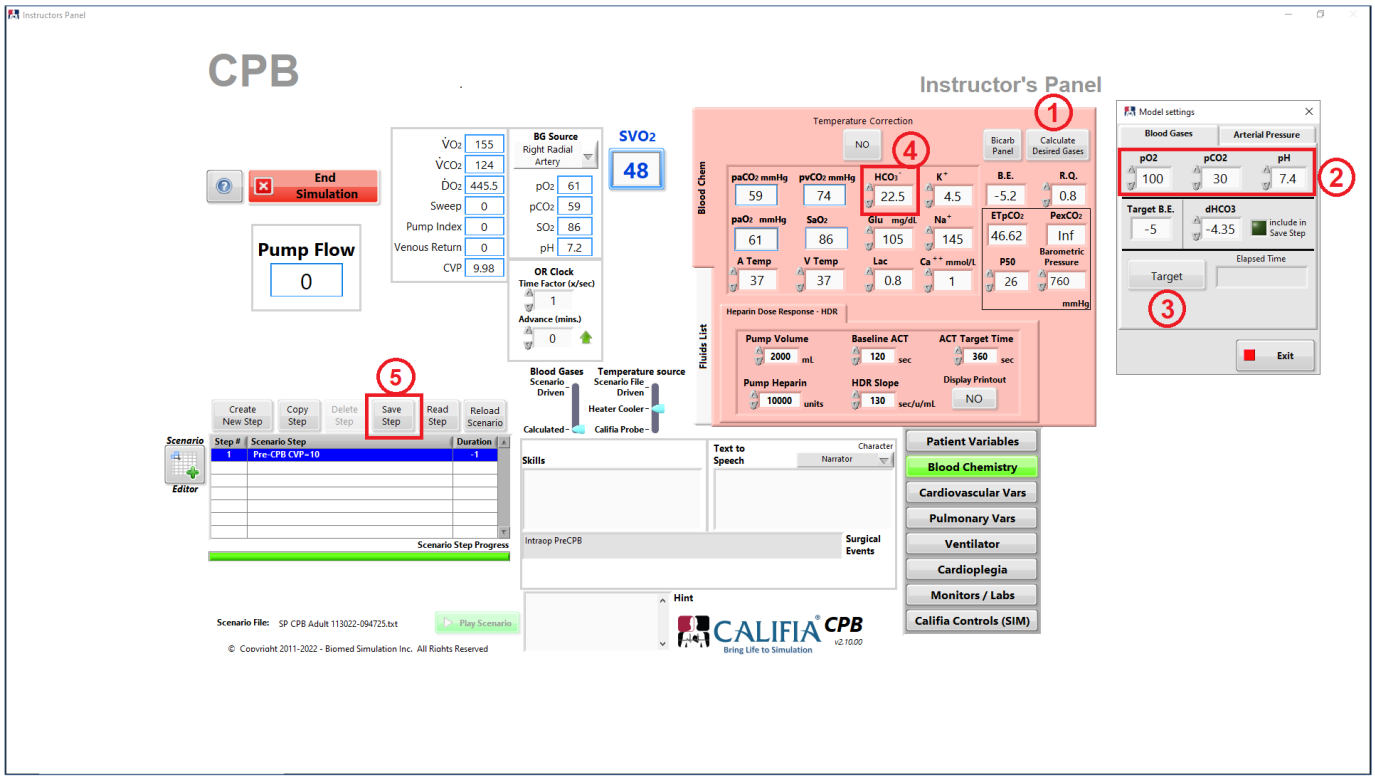

Figure 5.7 Set Blood Gases

5.9 Select Delivery and Drainage Cannulas

Refer to Figure 5.8 to select Delivery (arterial) and Drainage (venous) Cannulas. In **Instructor's Panel** » **Califia Controls**,

① Press **Cannula Editor** button.

②**a** In **Cannula Editor**, select a **Delivery Cannula** from drop-down list then press **Apply** button.

③**a** Cannula label and corresponding valve opening is shown.

②**b** Change to **Drainage Cannula**, select cannula from drop-down list then press **Apply** button.

③**b** Cannula label and corresponding valve opening is shown.

Exit Cannula Editor.

Pressure-Flow profiles for cannulas are modeled using respective electro-mechanical valves in CPM. The same performance profiles are used in SIM mode.

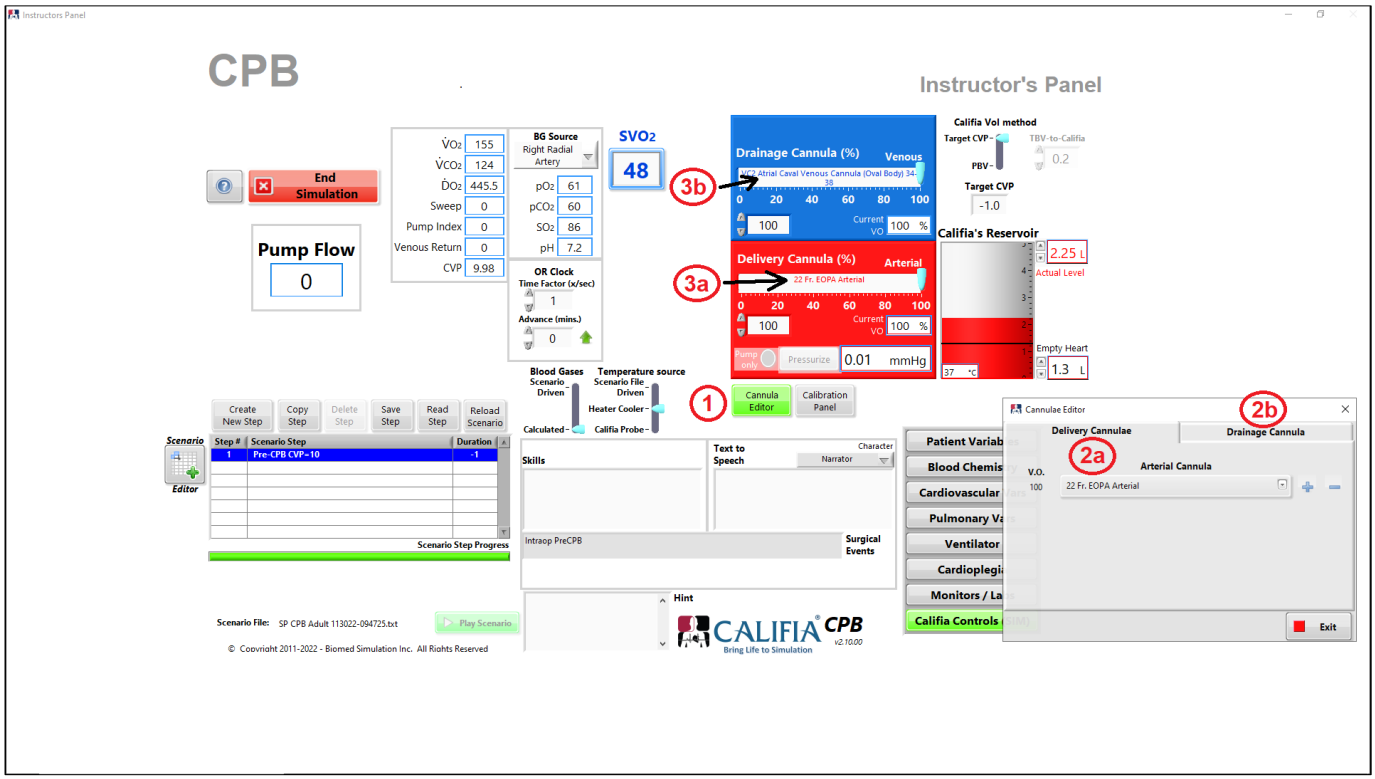

Figure 5.8 Cannula selection

5.10 Set Gas Blender

Refer to Figure 5.9, gas blender settings are set in the learner screen.

① Bring up bottom ribbon and select **Oxygenator Controls** button.

② Set **Gas Sweep Rate**, say ***2 LPM***.

③ Set **Oxygenator FiO_2** by pressing green button then turning knob, say ***100%***.

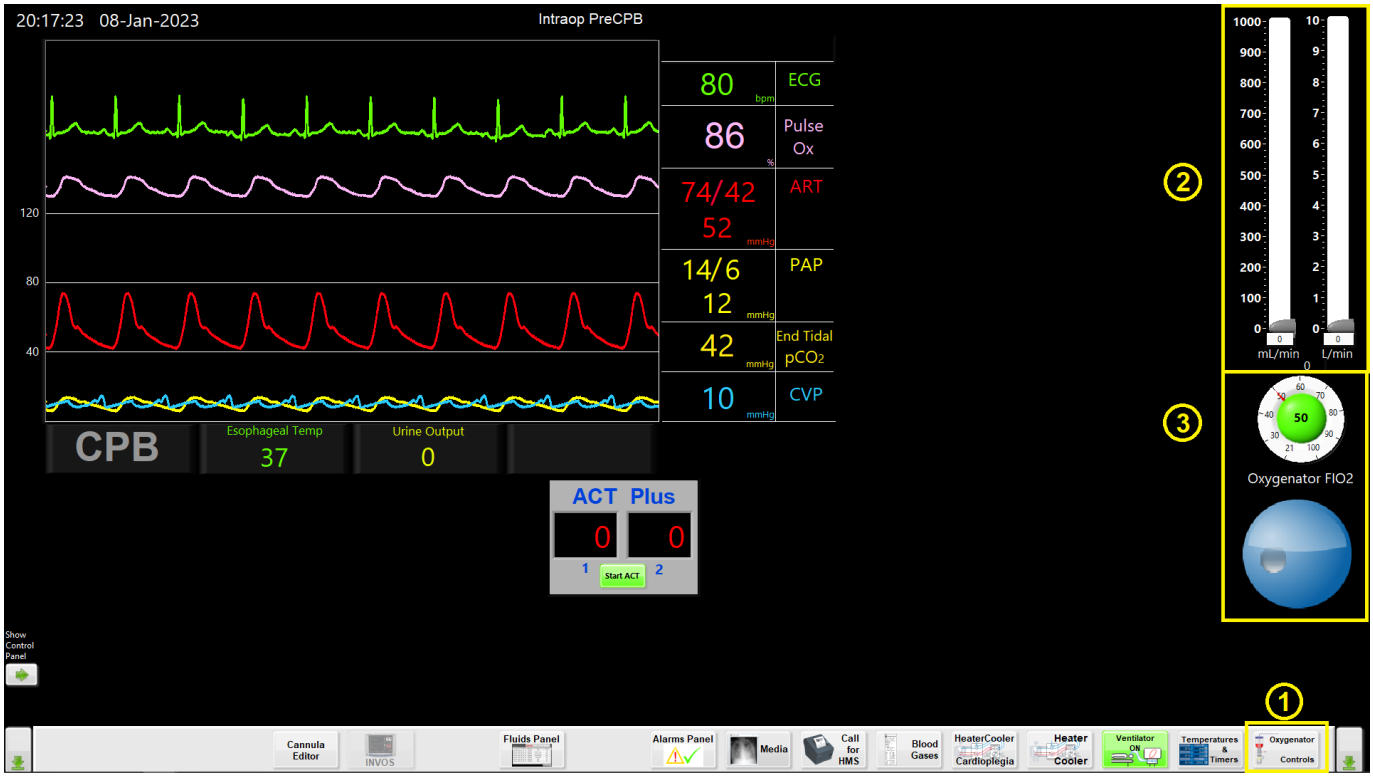

Figure 5.9 Set Gas Blender

5.11 Let's go on pump!

Califia Patient Module

Remove clamp on venous drainage line to drain patient while flowing using systemic pump.

Notice **Arterial Pressure** and **CVP** values decreasing as patient transitions support to heart lung machine, Figure 5.10.

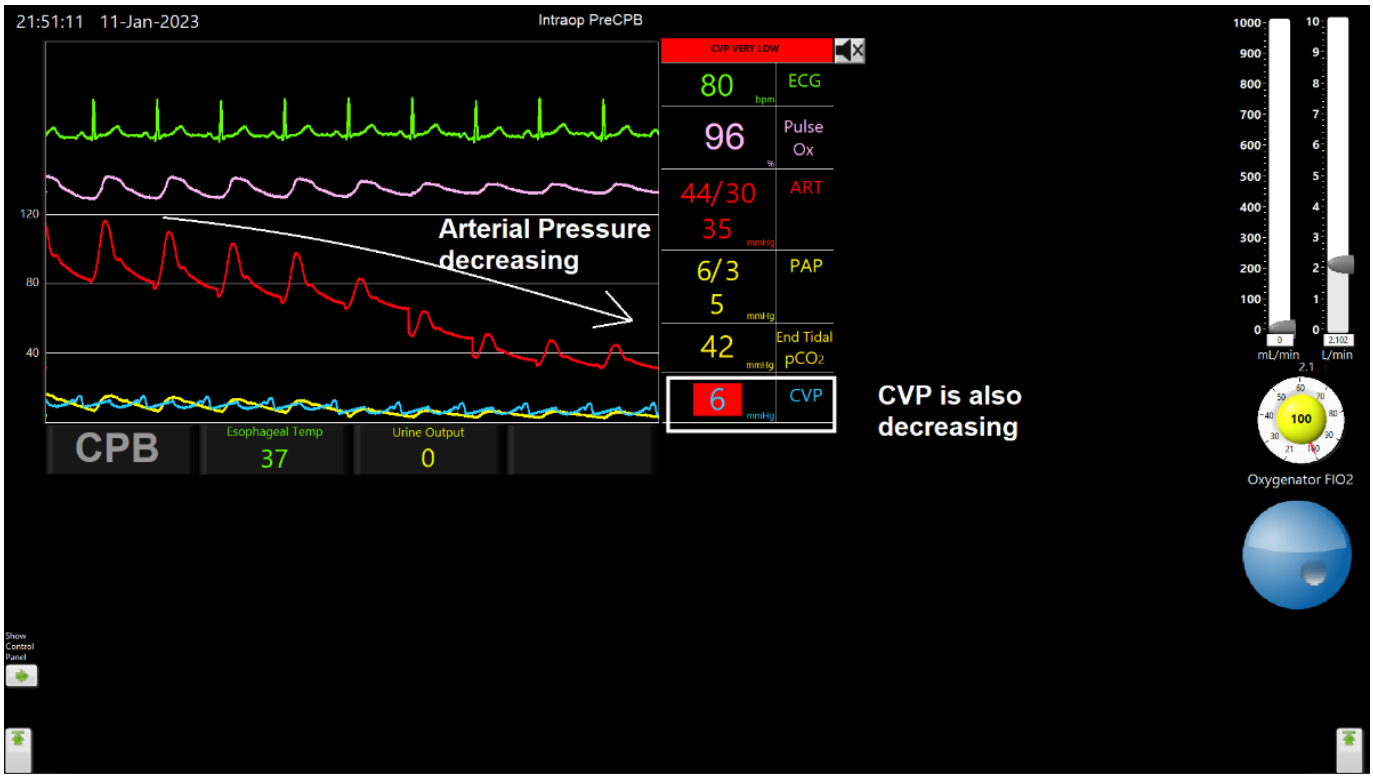

Figure 5.10 Arterial and CVP decreasing.

SIM

Prime virtual circuit, refer to Figure 5.11.

Bring up bottom ribbon,

① Press **Fluids Panel** button.

② Press **HLM Controls** button.

In **Fluids Panel,**

③a Select **Crystalloid** from Fluids drop-down menu.

③b Enter ***1000*** *mL* of Volume.

③c Light up the **Priming** button.

③d Press **Apply** button.

④ Notice **Venous Reservoir** fills up with this priming volume.

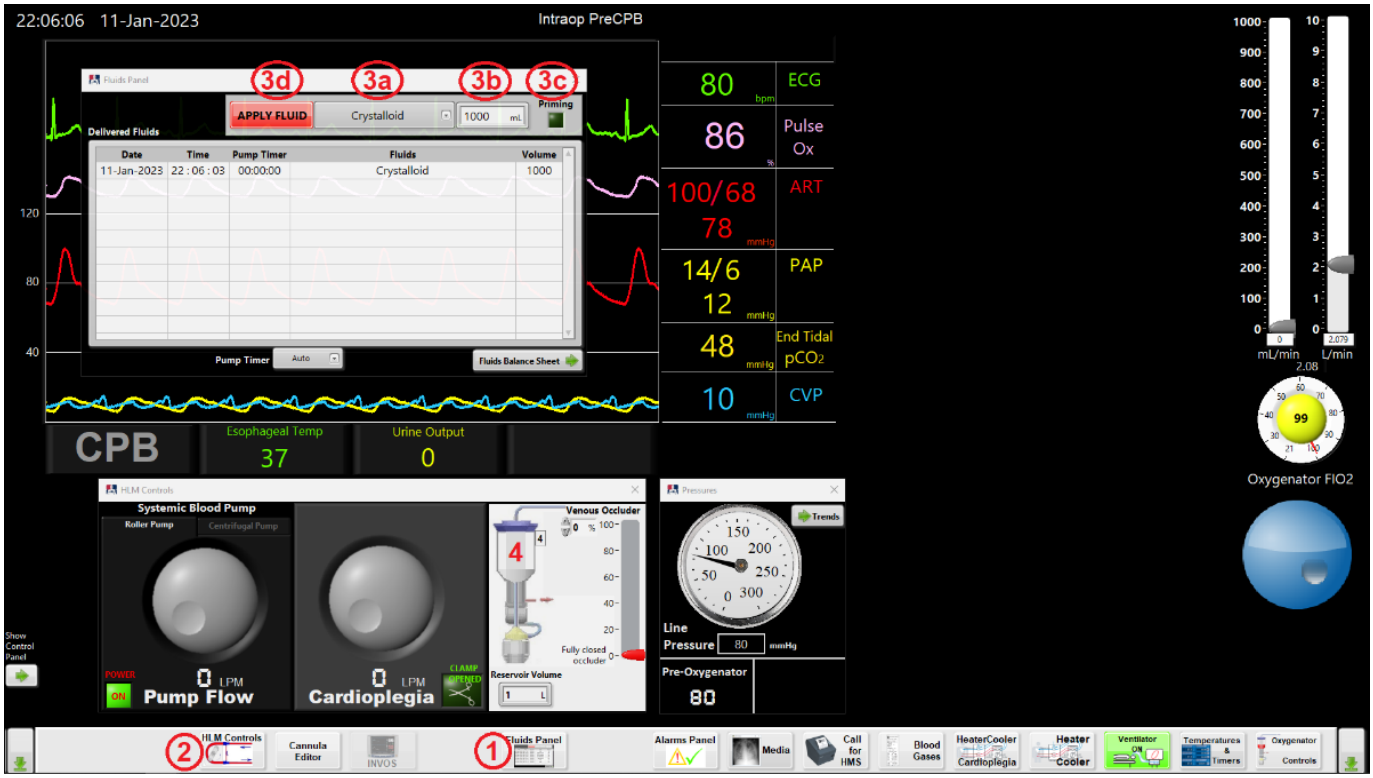

Figure 5.11 Prime circuit using Fluids Panel

To go on bypass, refer to Figure 5.12.

① Gradually open **Venous Occluder.**

② Start increasing systemic pump flow.

Virtual systemic pump is a roller pump; hence flow rate is dictated as opposed to speed (RPM).

③ Observe arterial pressure waveform flattening. As flow is increased, mean pressure rises.

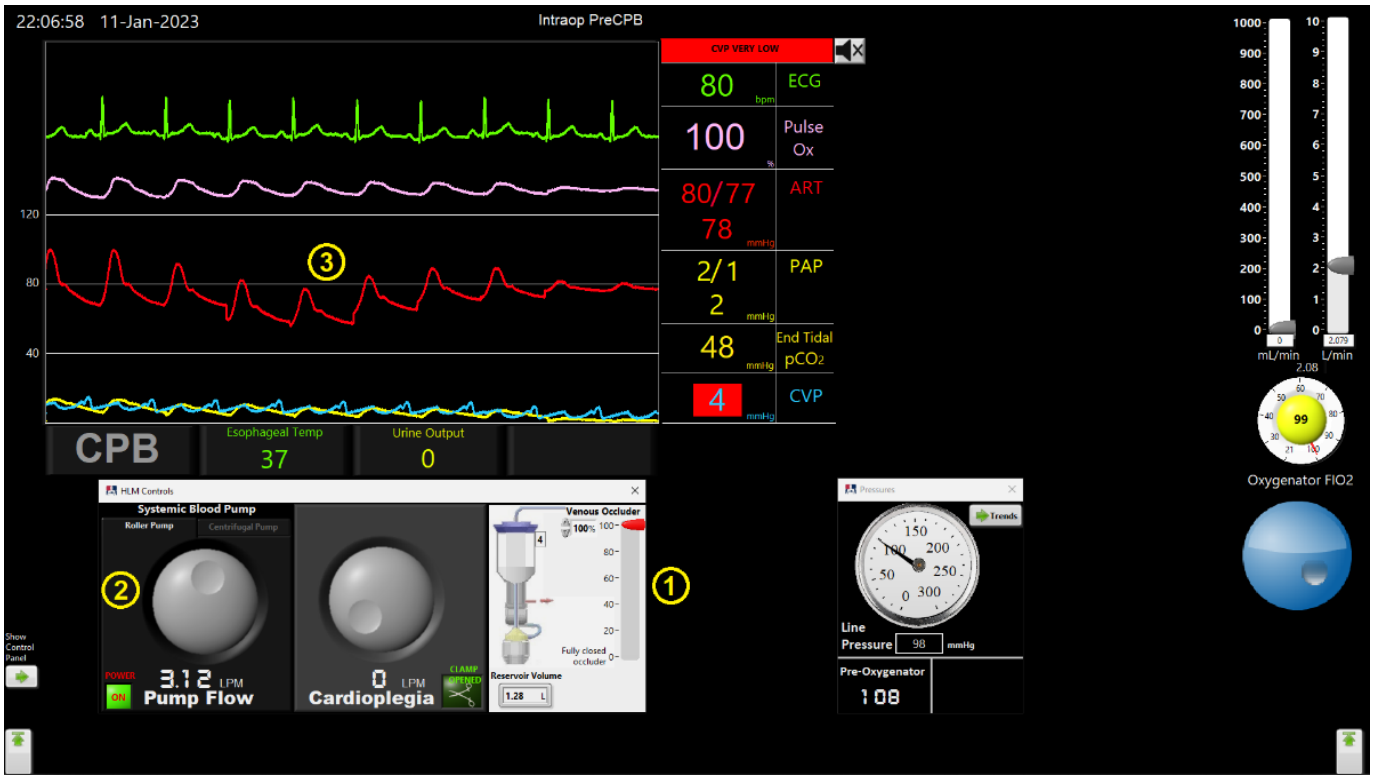

Figure 5.12 Starting bypass (SIM)

5.12 Give Cardioplegia

Refer to Figure 5.13, in **Instructor's Panel » Cardioplegia**,

① Set slider to **Ante** (Antegrade Cardioplegia delivery).

② Close **X Clamp.**

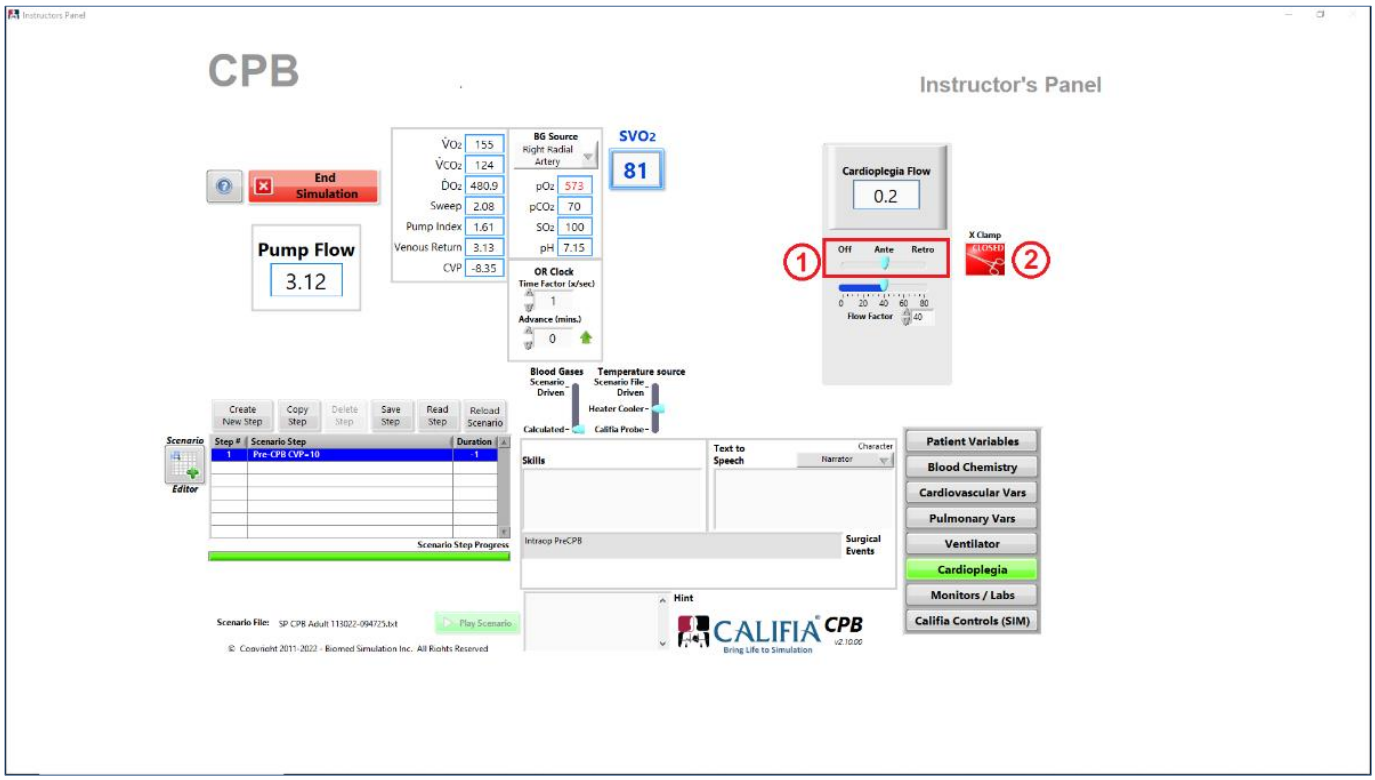

Figure 5.13 Prepare for Cardioplegia delivery

Califia Patient Module

Flow into Cardioplegia port. As flow is registered in the simulation software, the heart ECG will sequence through waveform patterns until the heart is completely arrested, Figure 5.14.

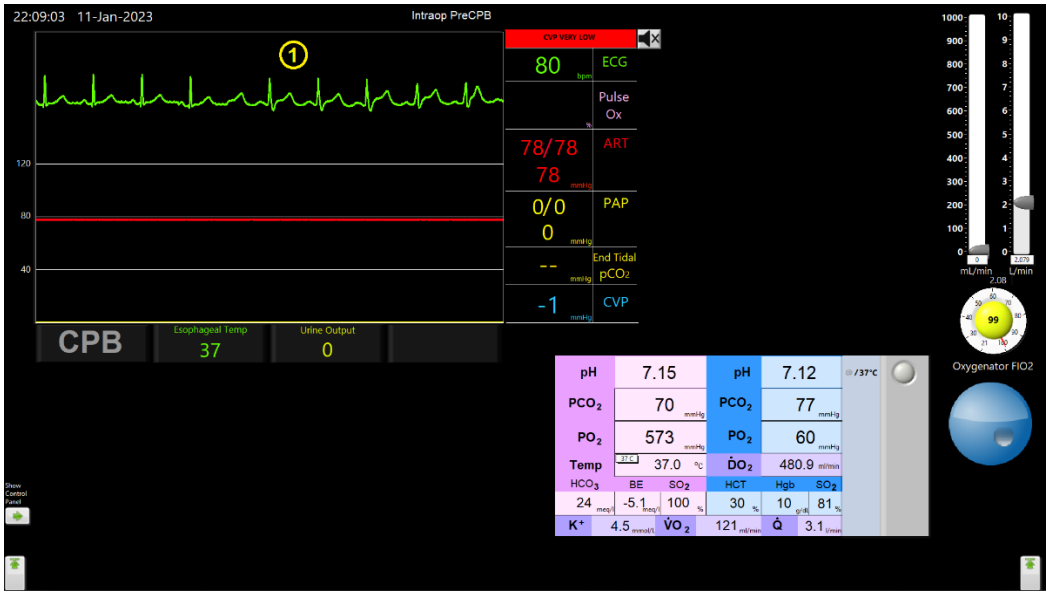

Figure 5.14 Heart ECG under Cardioplegia delivery

SIM

Refer to Figure 5.15:

1. Close **X Clamp** in **HLM Controls** panel.
2. Increase **Cardioplegia** pump flow.
3. Notice **ECG** pattern change.

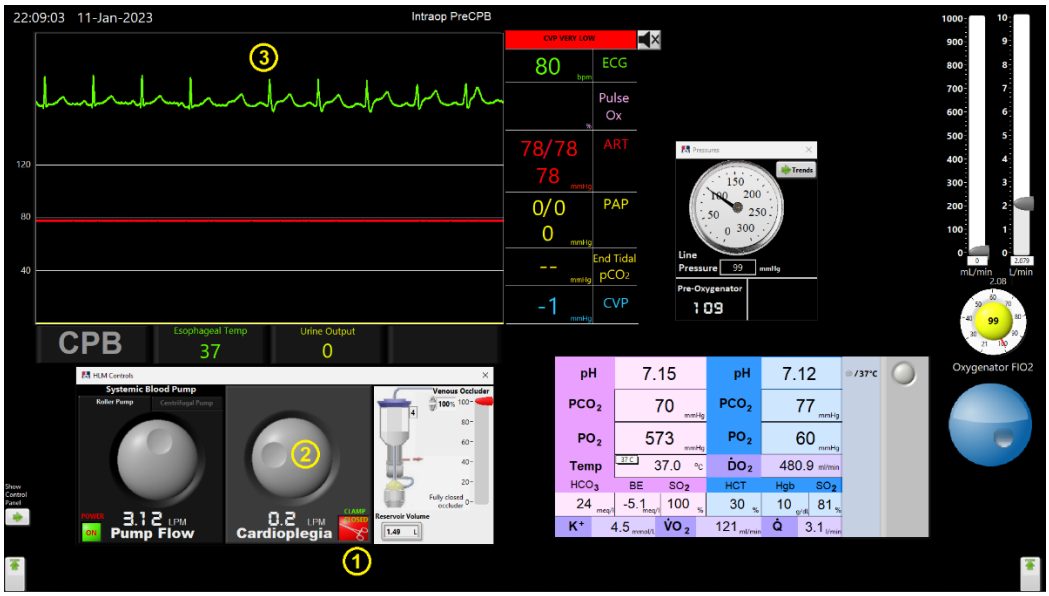

Figure 5.15 Heart ECG under Cardioplegia delivery (SIM)

5.13 Event: Cannula malposition

Refer to

Figure 5.16, in **Instructor's Panel » Califia Controls**,

① Set **Delivery Cannula (%)** slider to about ***25%.***

② Arterial line pressure increases.

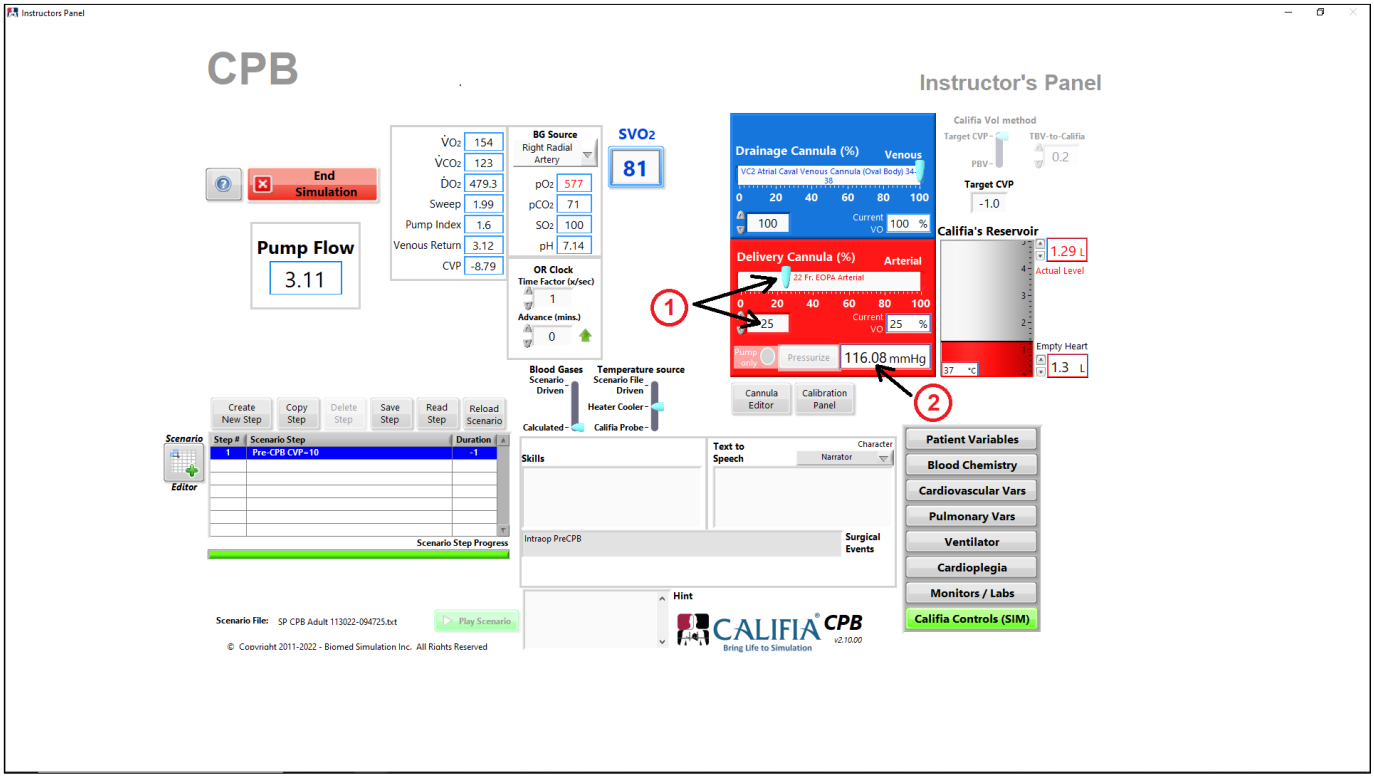

Figure 5.16 Arterial Cannula set to 25% opened

Arterial line pressure should report a high value due to high resistance generated by the smaller arterial valve opening, Figure 5.17.

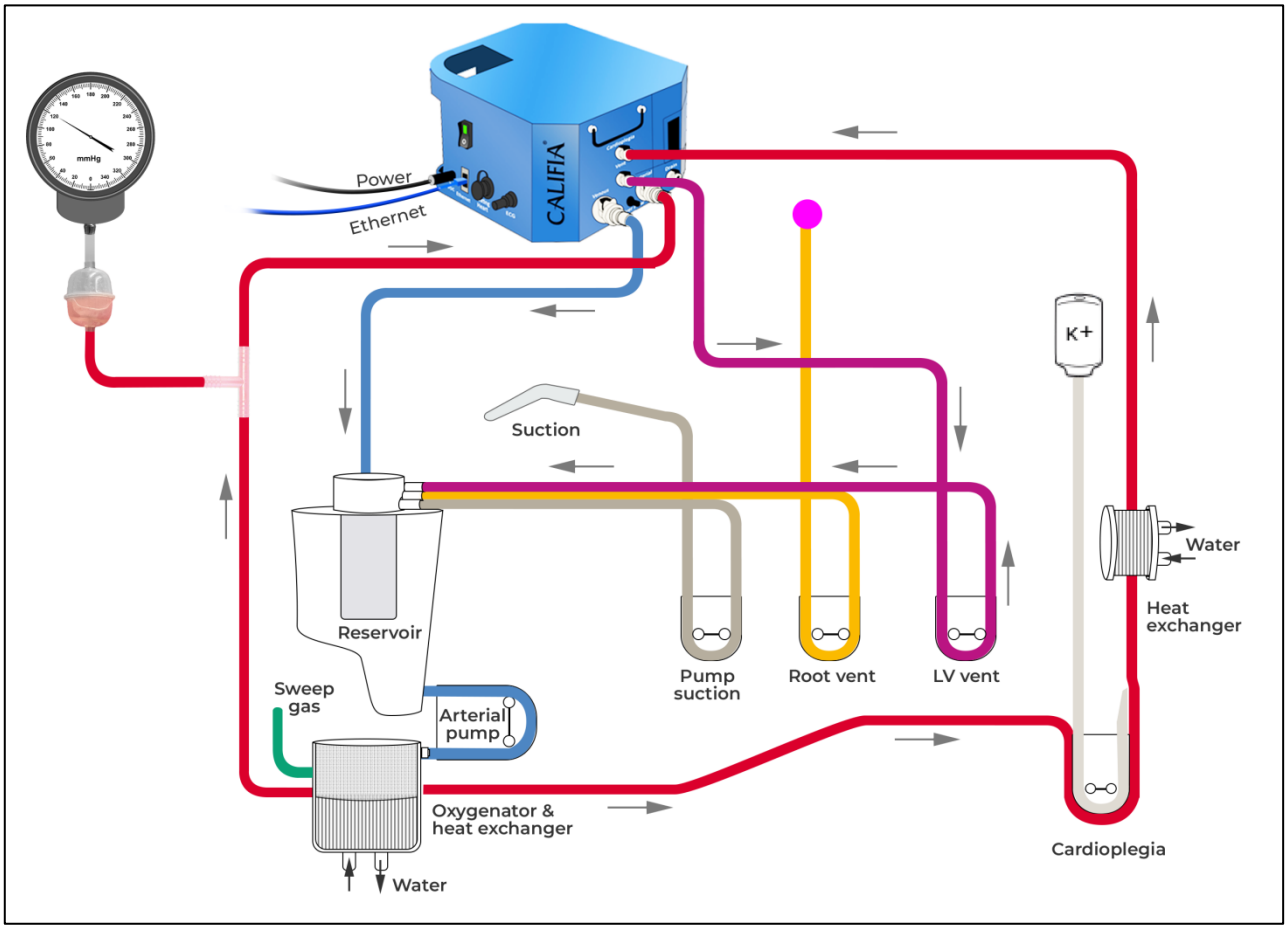

Figure 5.17 High line pressure

Main pump type (Arterial pump)

Roller pump

High line pressure is expected until the pump's speed is lowered.

Centrifugal pump

High line pressure should be experienced momentarily, flow rate decreases and pressure drops somewhat.

SIM

Due to the high resistance generated by the smaller arterial valve opening, the arterial line pressure displayed in the **Pressures** panel is very high, Figure 5.18.

Line pressure (post-Oxygenator): 168 mmHg.

Pre-Oxygenator pressure: 178 mmHg.

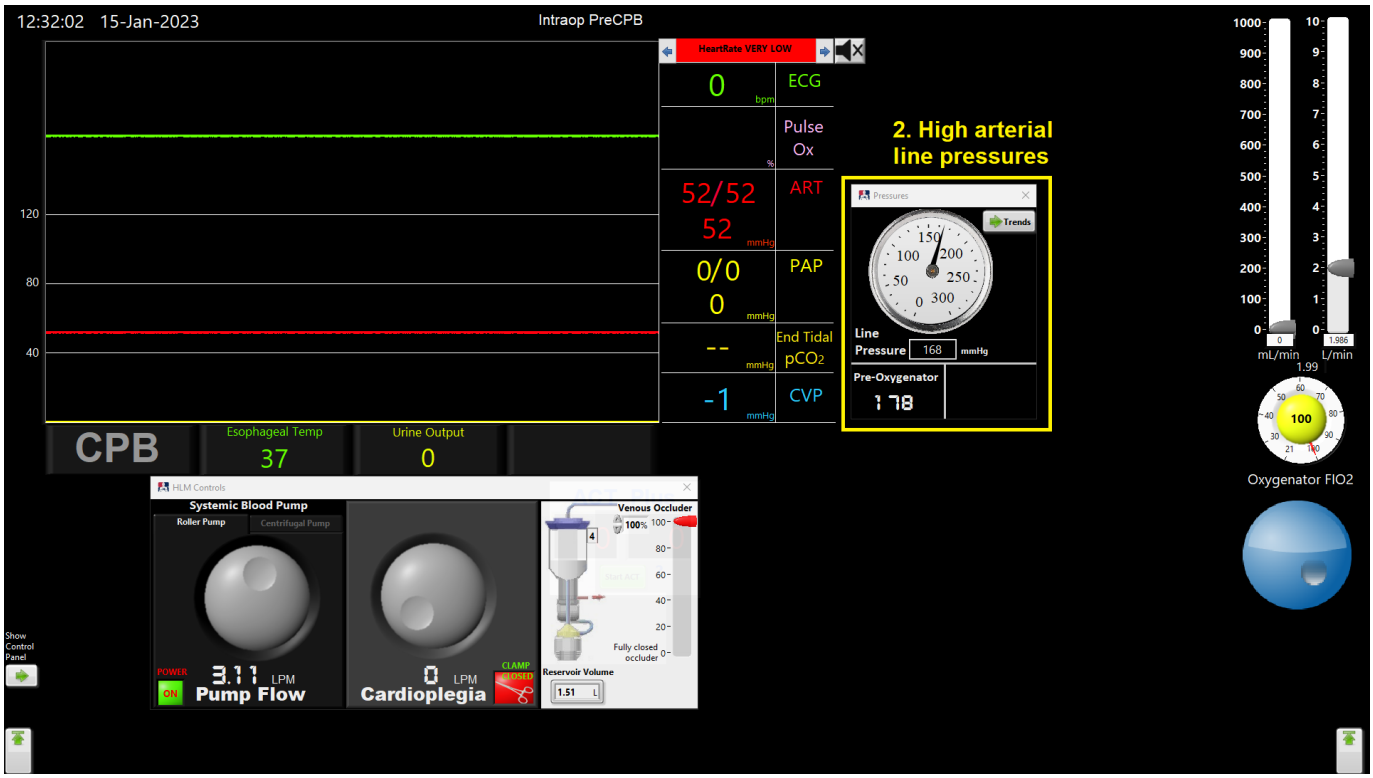

Figure 5.18 High arterial line pressures (SIM)

Set **Delivery Cannula (%)** back to ***100%*** once the event is resolved.

5.14 Remove Cross Clamp

Califia Patient Module

Refer to Figure 5.19,

① Open Cross Clamp in **Instructor's Panel » Cardioplegia.**

② Notice **ECG** pattern return to activity, ending in **SR** (Sinus Rhythm).

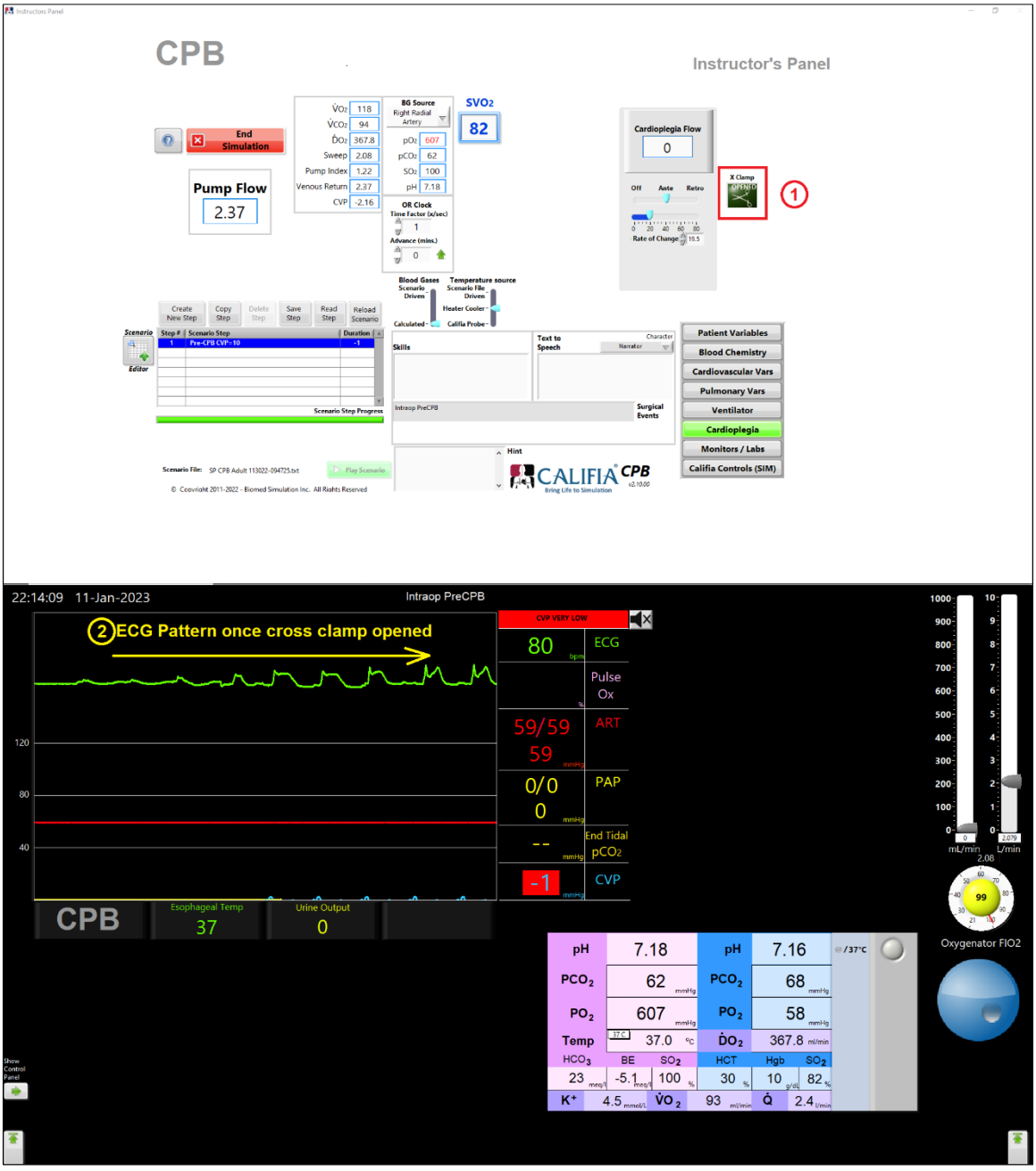

Figure 5.19 Open Cross Clamp

SIM

Refer to Figure 5.20,

① Open Cross Clamp in **HLM Controls** panel.

② Notice **ECG** pattern return to activity, ending in **SR**.

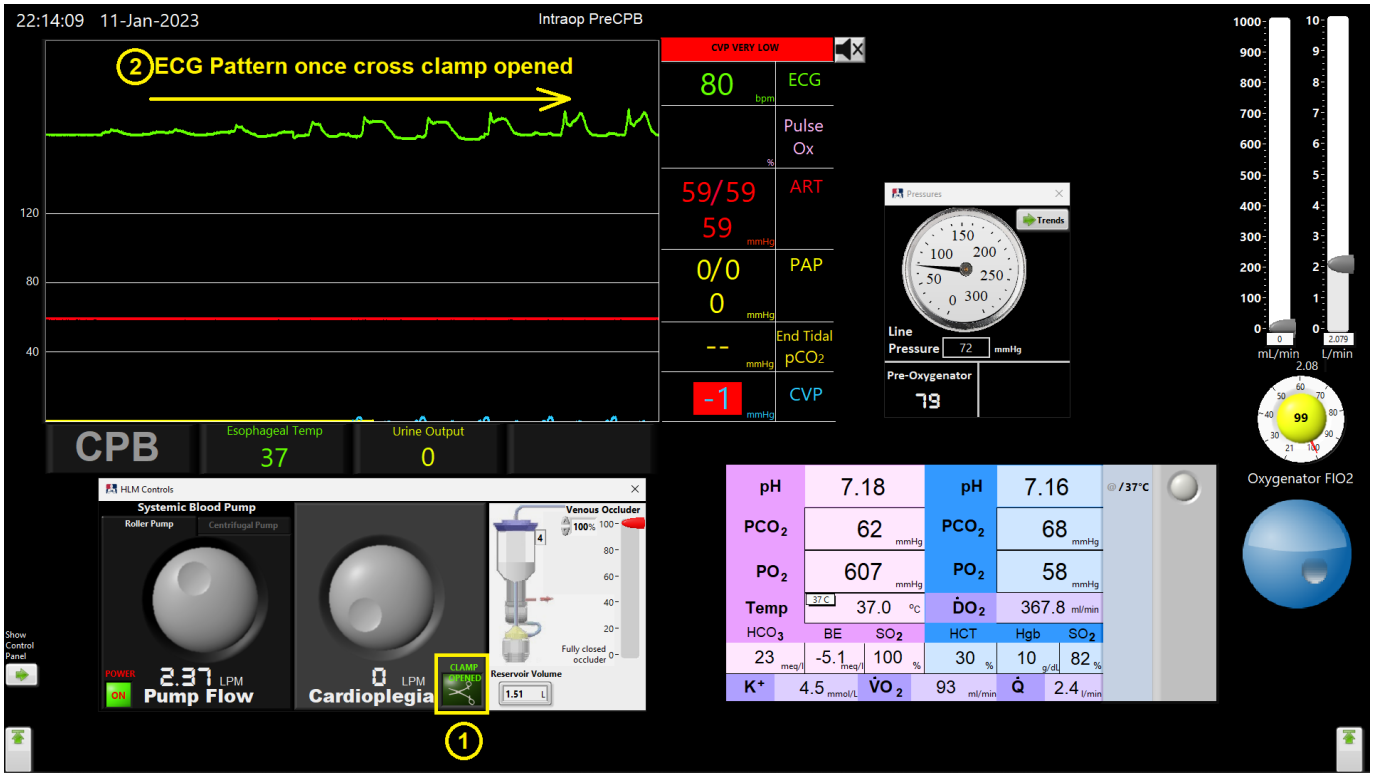

Figure 5.20 Open Cross Clamp (SIM)

5.15 Come off pump!

Califia Patient Module

Refer to Figure 5.21,

Start weaning by partially occluding venous drain and filling patient.

① Notice patient's heart starts to eject and venous pressure increases.

Come-off systemic pump as patient's arterial pressure returns to normal and CVP meets target value.

② Heart has taken over full body perfusion and CVP is normal value.

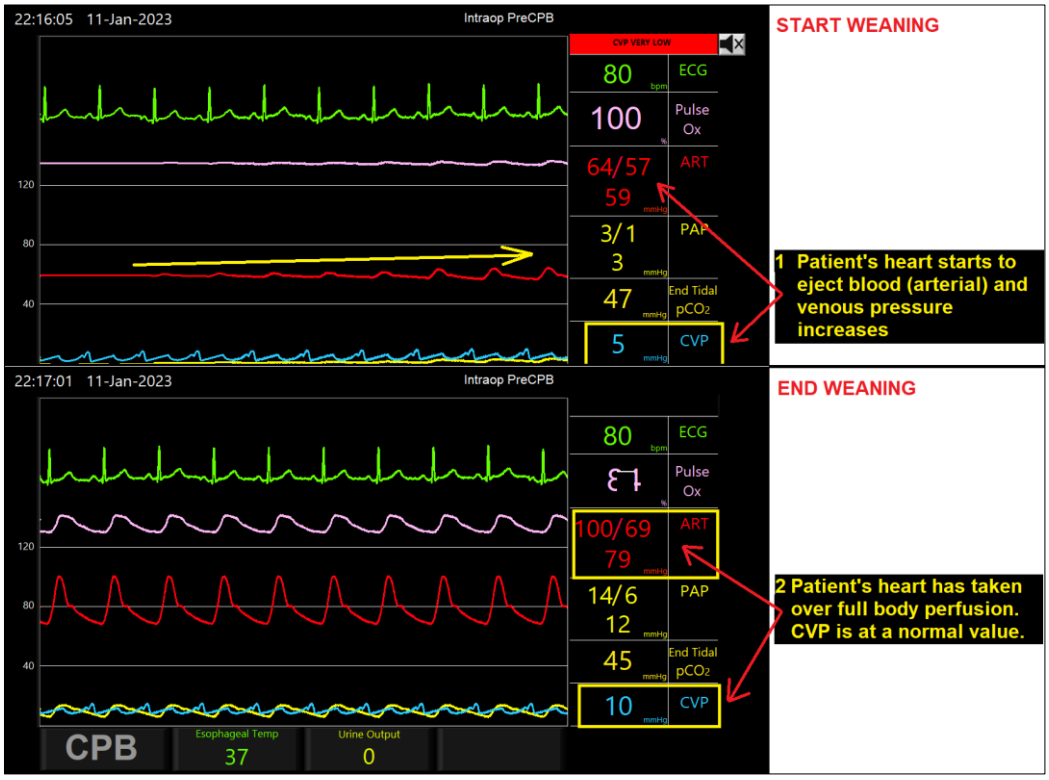

Figure 5.21 Wean off pump

SIM

Refer to Figure 5.22.

① Start weaning by partially occluding venous drain and filling patient.

② Notice patient's heart starts to eject and venous pressure increases.

③ Come-off systemic pump as patient's arterial pressure returns to normal and CVP meets target value.

④ Heart has taken over full body perfusion and CVP is normal value.

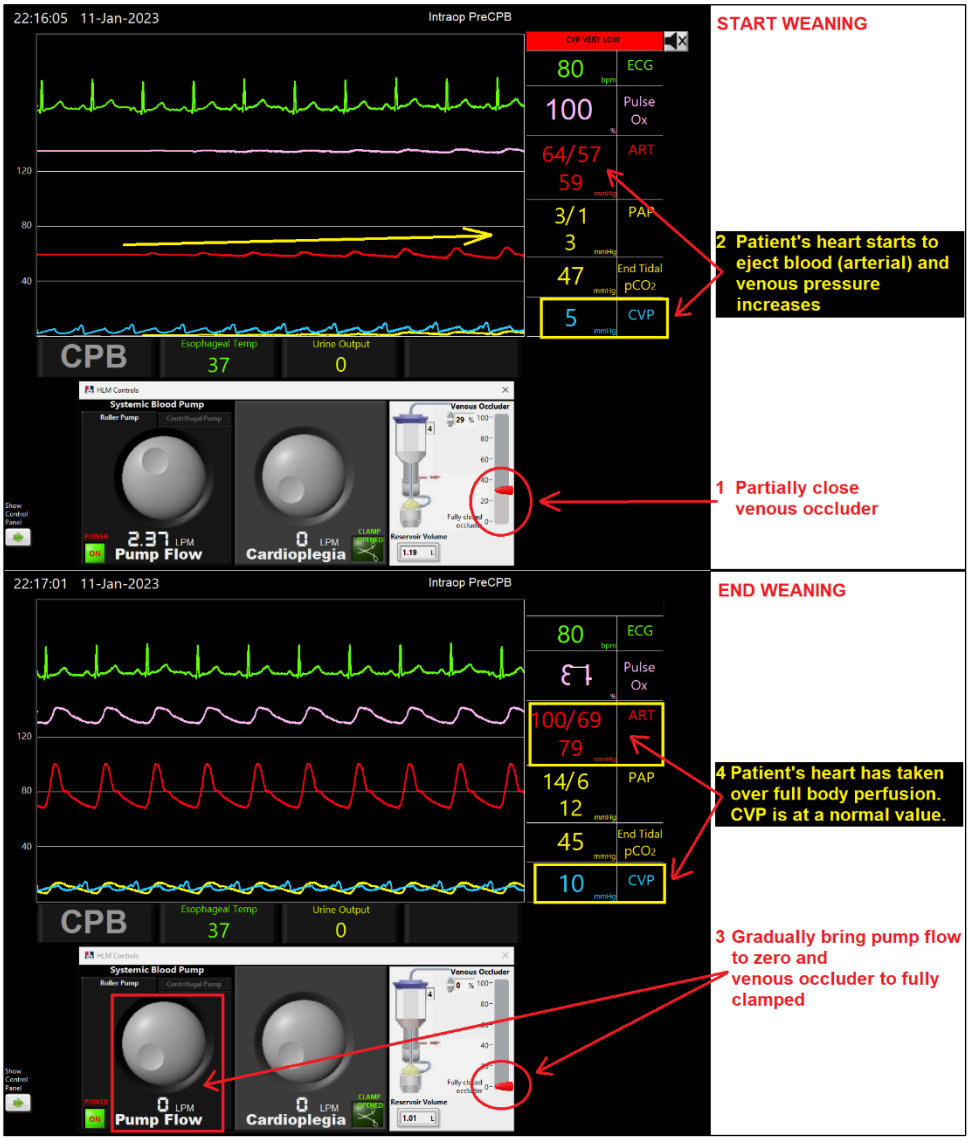

Figure 5.22 Wean off pump (SIM)

5.16 Return to Opening Screen

Refer to Figure 5.23, press **End Simulation** button, ①; confirm request to return to **Opening Screen**, ②.

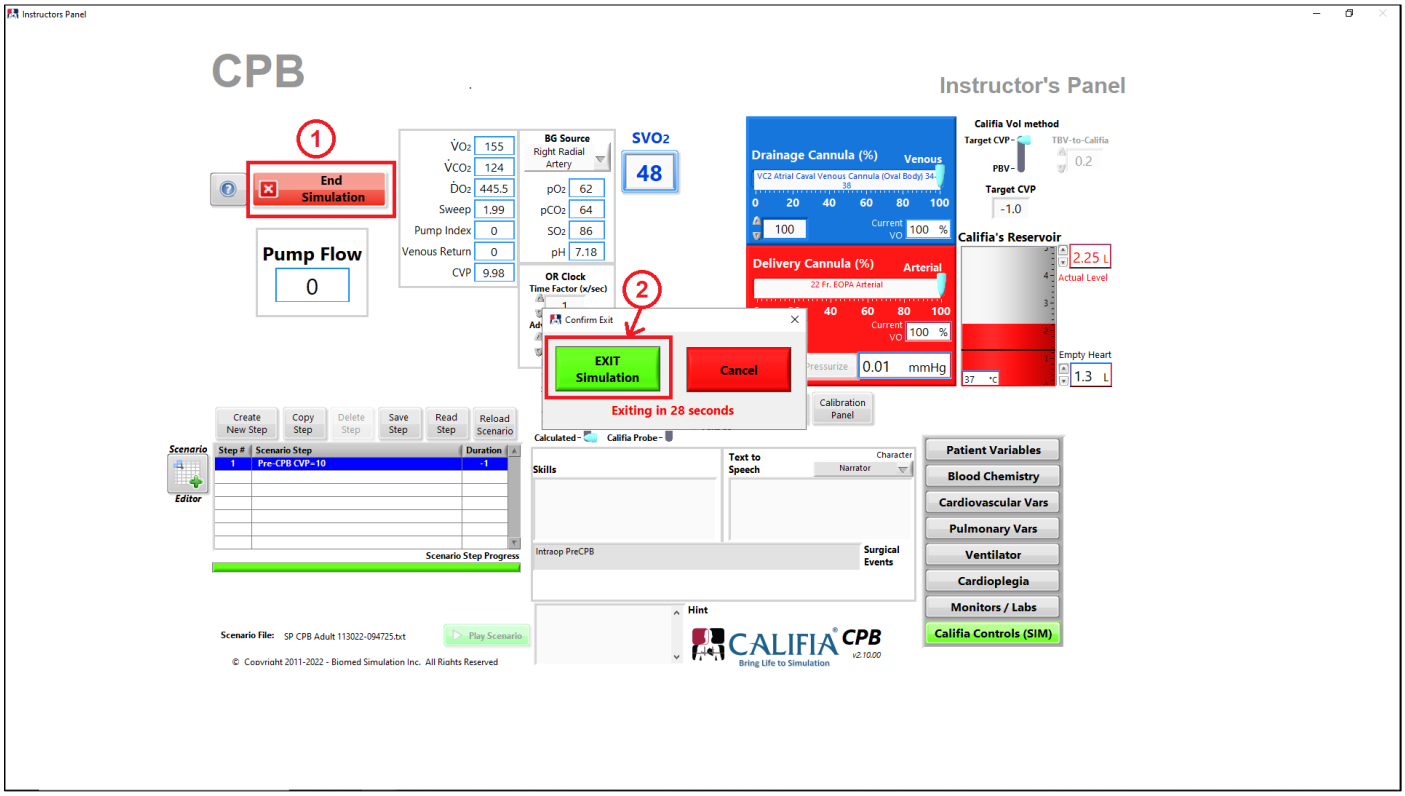

Figure 5.23 End Simulation

5.17 Create a CPB Simulation Scenario File

In this section, we will repeat the CPB case presented in this chapter however we will save all stages into a scenario file.

5.17.1 Access Scenario Editor

Refer to Figure 5.24, Press **MENU** button, ①, followed by **Scenario Editor** button, ②.

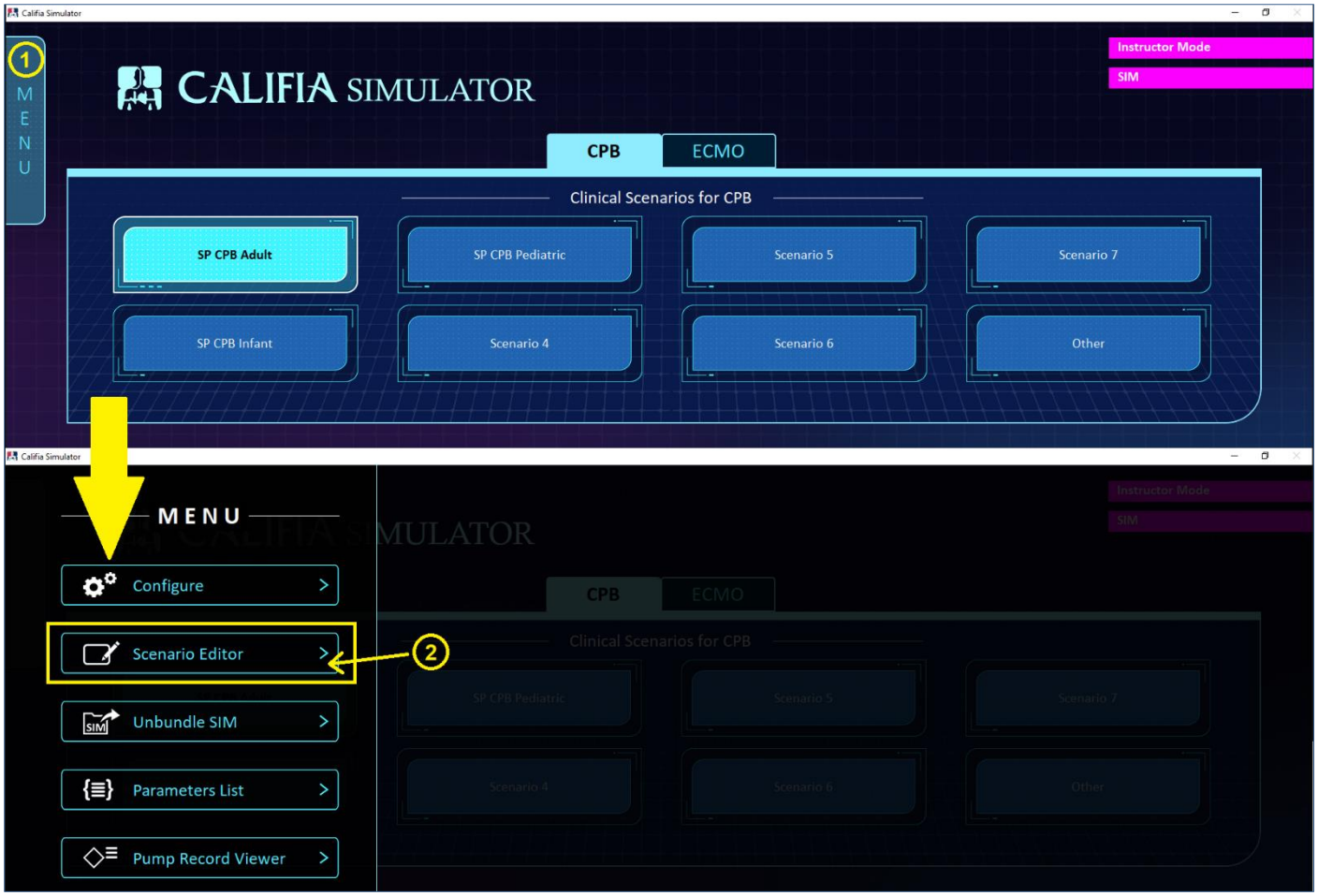

Figure 5.24 Access MENU in Opening Screen then Scenario Editor

5.17.2 Save Scenario File

Refer to Figure 4.26, in **Scenario Editor**,

① Press **File** menu selection

② Select **Save As…**

③ Enter a new scenario file name such as *Getting Started – CPB Scenario*

This name is used to create a folder which will host the scenario file and ventilator.ini file.

[Optional] – the **Button Selector** defaults to **Other** however a different button can be programmed to be associated with the new scenario file.

④ Press the **Create** button to complete the new scenario file creation.

Notice the **Scenario Editor** panel title reflects the new folder location and file name.

⑤ Once the new scenario file and folder are created, return to **File** menu and press **Close.**

Press **Close** button to close the **MENU** bar, this step is not shown.

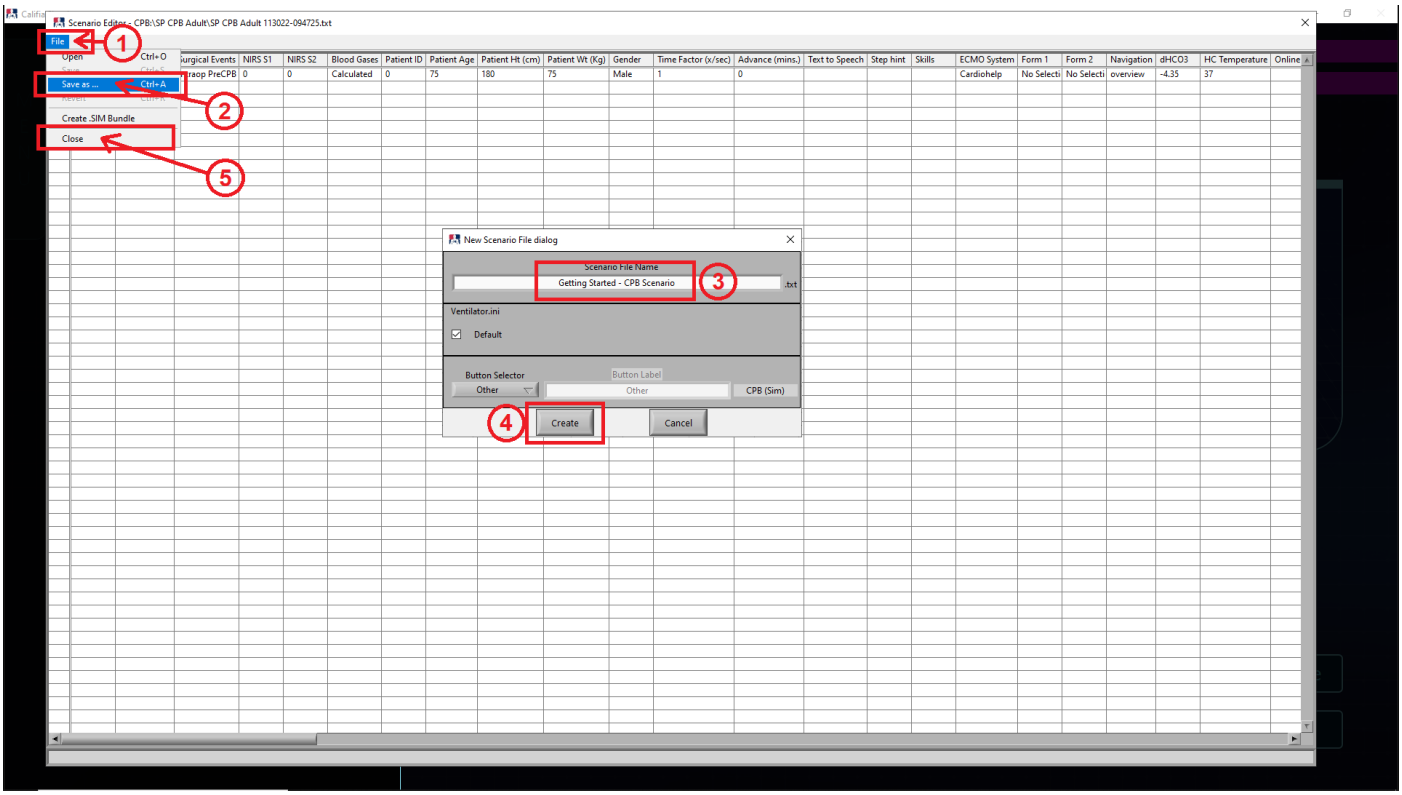

Figure 5.22 Save As... dialog in Scenario Editor

5.17.3 New scenario file in Opening Screen

Refer to Figure 5.27, **Opening Screen,**

① **Location of Scenario File** points to the newly created Scenario File.

② The selected button is **Other** as previously specified in the **Save As…** dialog.

③ Press **Continue** button to load new scenario file.

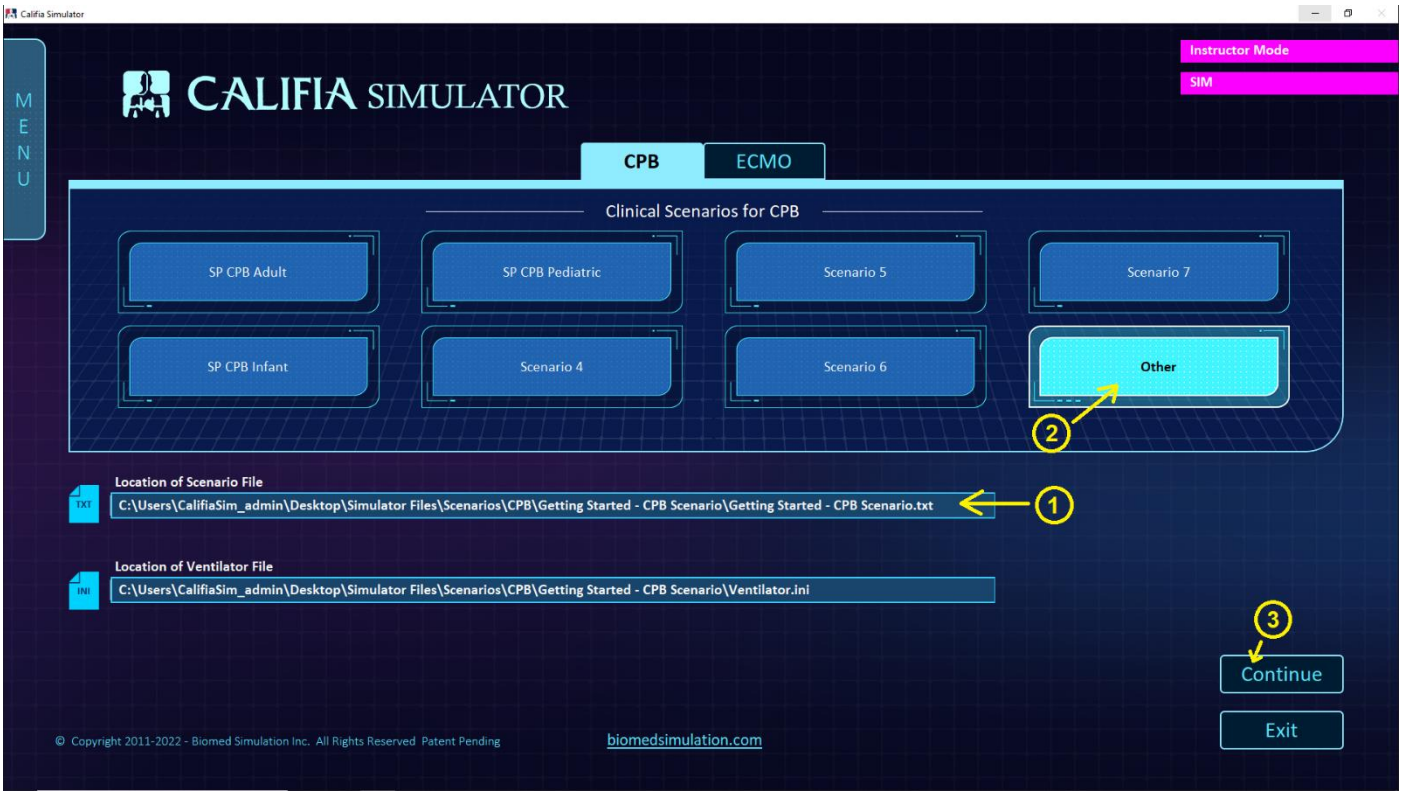

Figure 5.23 Opening Screen - New Scenario File

5.17.4 Scenario File Step 2: Select cannulas

The original scenario file was saved with patient's blood gases configured as desired, refer to Section 4.7.

Next is to select cannulas. Follow these steps in **Instructor's Panel**, refer to Figure 5.28.

① Press **Create New Step**

② Step #2 is added to scenario table; type ***Select cannulas*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

3 Follow steps in Section 4.8 to select cannulas.

④ Press **Save Step**** button.

** refers to the step having been modified and needs to be saved.

⑤ In the **Confirm Scenario File write** dialog, select both **Drainage Cannula** and **Delivery Cannula 1.**

Hold <*Ctrl*> key to select multiple entries.

⑥ Press **Confirm** button to save selected step changes to scenario file.

Original scenario file is not overwritten. A new one is created in the same work folder; its filename includes a timestamp.

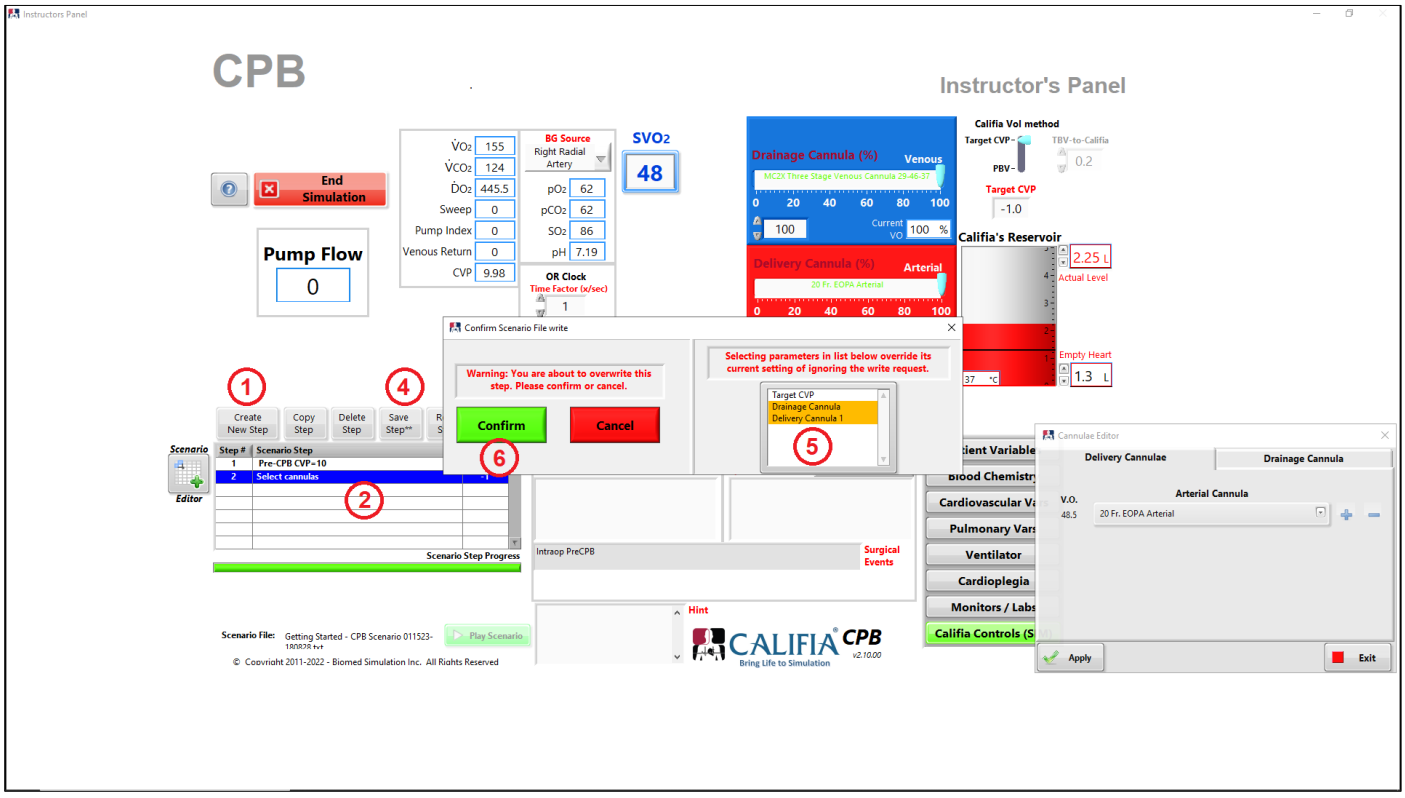

Figure 5.24 Step 2 edits

5.17.5 Scenario File Step 3: Go on pump

Follow these steps, refer to Figure 5.29,

① Press **Create New Step.**

② Type ***Let's go on pump*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following note in **Skills** field: ***Set gas blender and go on pump.***

④ Add following in **Surgical Events**: ***Go on pump.***

This is displayed along the top of the Learner Screen.

5 Follow steps in Section 4.9 to set gas blender and Section 4.10 to go on pump.

⑥ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑦ In the **Confirm Scenario File write** dialog, select both **Skills** and **Surgical Events.**

Hold <*Ctrl*> key to select multiple entries.

⑧ Press **Confirm** button to save step changes to scenario file.

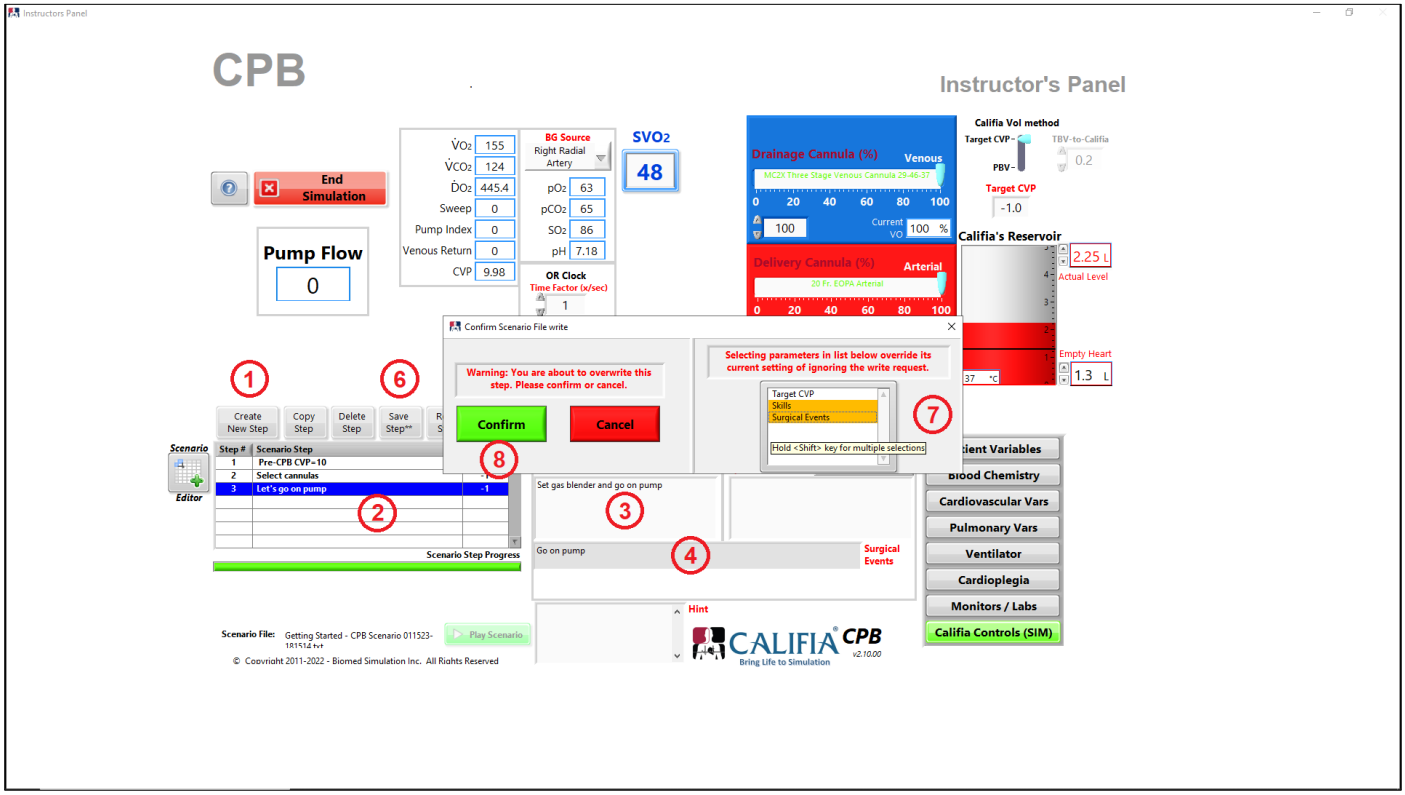

Figure 5.29 Step 3 edits

5.17.6 Scenario File Step 4: Give Cardioplegia

Follow these steps, refer to Figure 5.30,

① Press **Create New Step.**

② Type ***Give Cardioplegia*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Remove existing note in **Skills** field.

④ Add following in **Surgical Events**: ***Give Cardioplegia.***

This is displayed along the top of the Learner Screen.

5 Follow steps in Section 4.11 to deliver cardioplegia.

⑥ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑦ In the **Confirm Scenario File write** dialog, select both **Cross Clamp** and **CP Delivery.**

Hold <*Ctrl*> key to select multiple entries.

⑧ Press **Confirm** button to save step changes to scenario file.

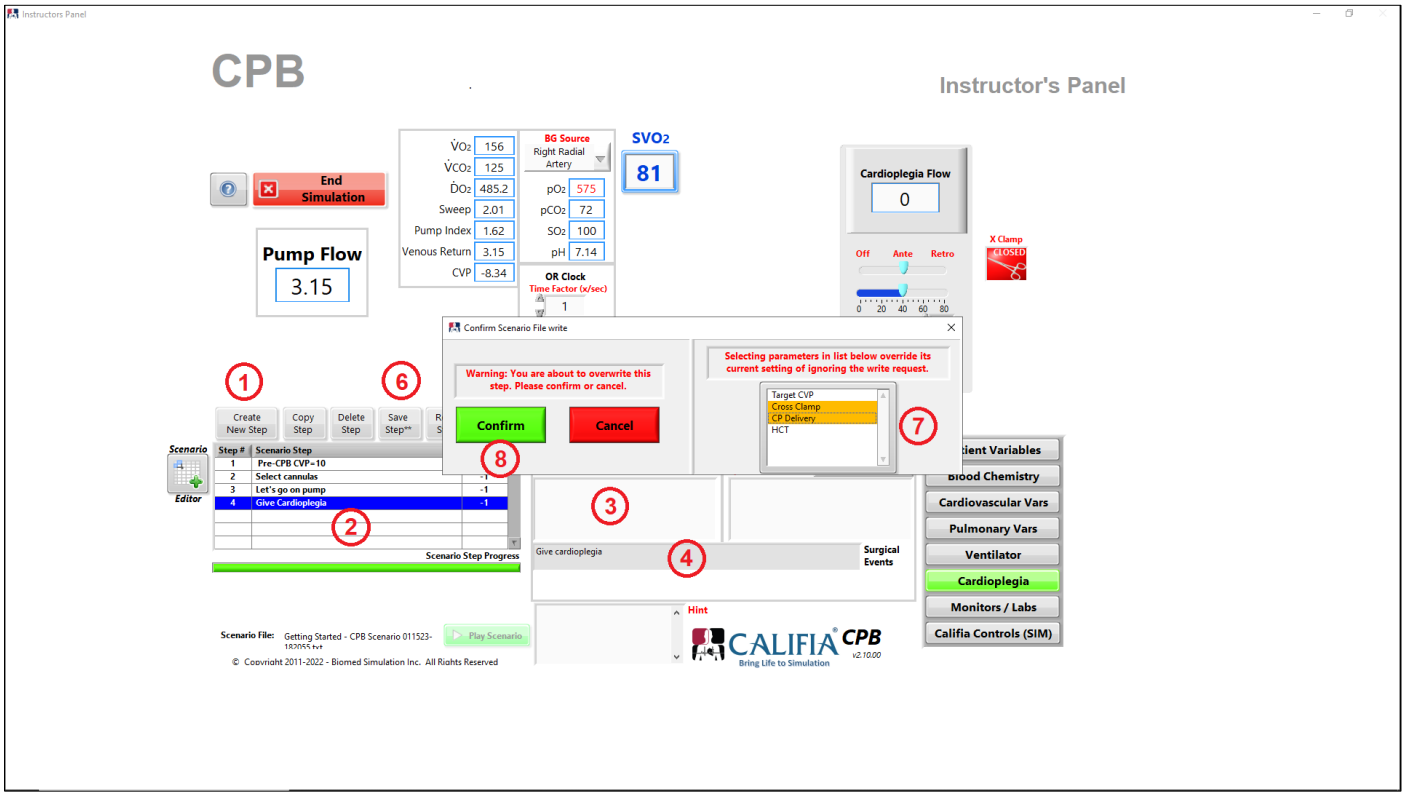

Figure 5.30 Step 4 edits

5.17.7 Scenario File Step 5: Event: Cannula malposition

Follow these steps, refer to Figure 5.31,

① Press **Create New Step.**

② Type ***Event – Cannula malposition*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Remove existing note in **Surgical Events** field.

4 Follow steps in Section 4.12 for Event: Cannula malposition.

⑤ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑥ In the **Confirm Scenario File write** dialog, select both **Delivery Cannula 1 (%)** and **Surgical Events.**

Hold <*Ctrl*> key to select multiple entries.

⑦ Press **Confirm** button to save step changes to scenario file.

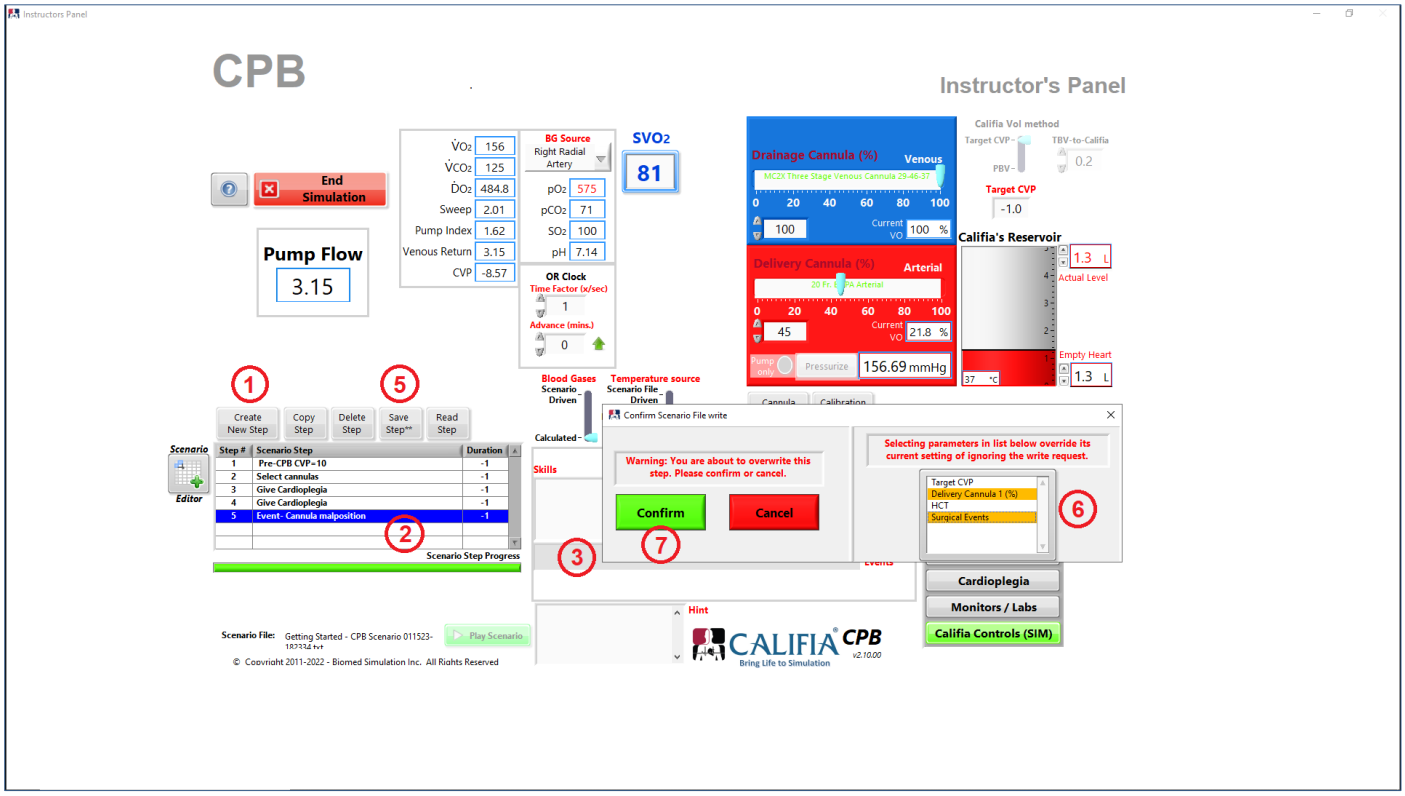

Figure 5.31 Step 5 edits

5.17.8 Scenario File Step 6: Open Cross Clamp

Follow these steps, refer to Figure 5.32,

① Press **Create New Step.**

② Type ***Open Cross Clamp*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following note in **Skills** field: ***Return Delivery Cannula to 100% and open cross clamp.***

4 Follow steps in Section 4.13 to Open Cross Clamp.

Also, set **Delivery Cannula (%)** to ***100%*** since cannula malposition event has been fixed.

⑤ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑥ In the **Confirm Scenario File write** dialog, select **Cross Clamp**, **Delivery Cannula 1 (%)** and **Skills.**

Hold <*Ctrl*> key to select multiple entries.

⑦ Press **Confirm** button to save step changes to scenario file.

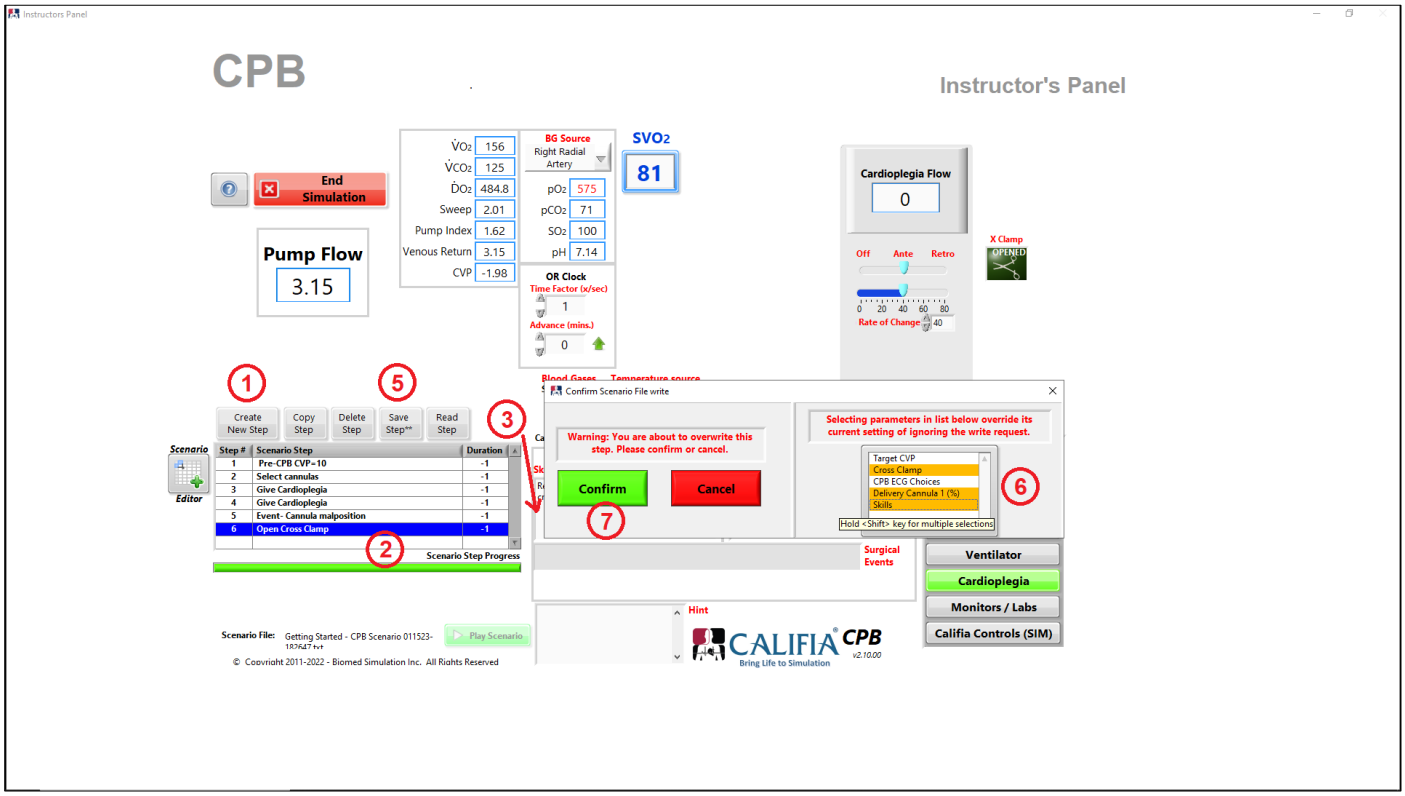

Figure 5.32 Step 6 edits

5.17.9 Scenario File Step 7: Come off pump

Follow these steps, refer to Figure 5.33,

① Press **Create New Step.**

② Type ***Come off pump*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Remove existing note in **Skills** field.

④ Follow steps in Section 4.14 to come off pump.

⑤ Press **Save Step**** button.

****** refers to the step having been modified and needs to be saved.

⑥ In the **Confirm Scenario File write** dialog, select **Skills.**

Hold <*Ctrl*> key to select multiple entries.

⑦ Press **Confirm** button to save step changes to scenario file.

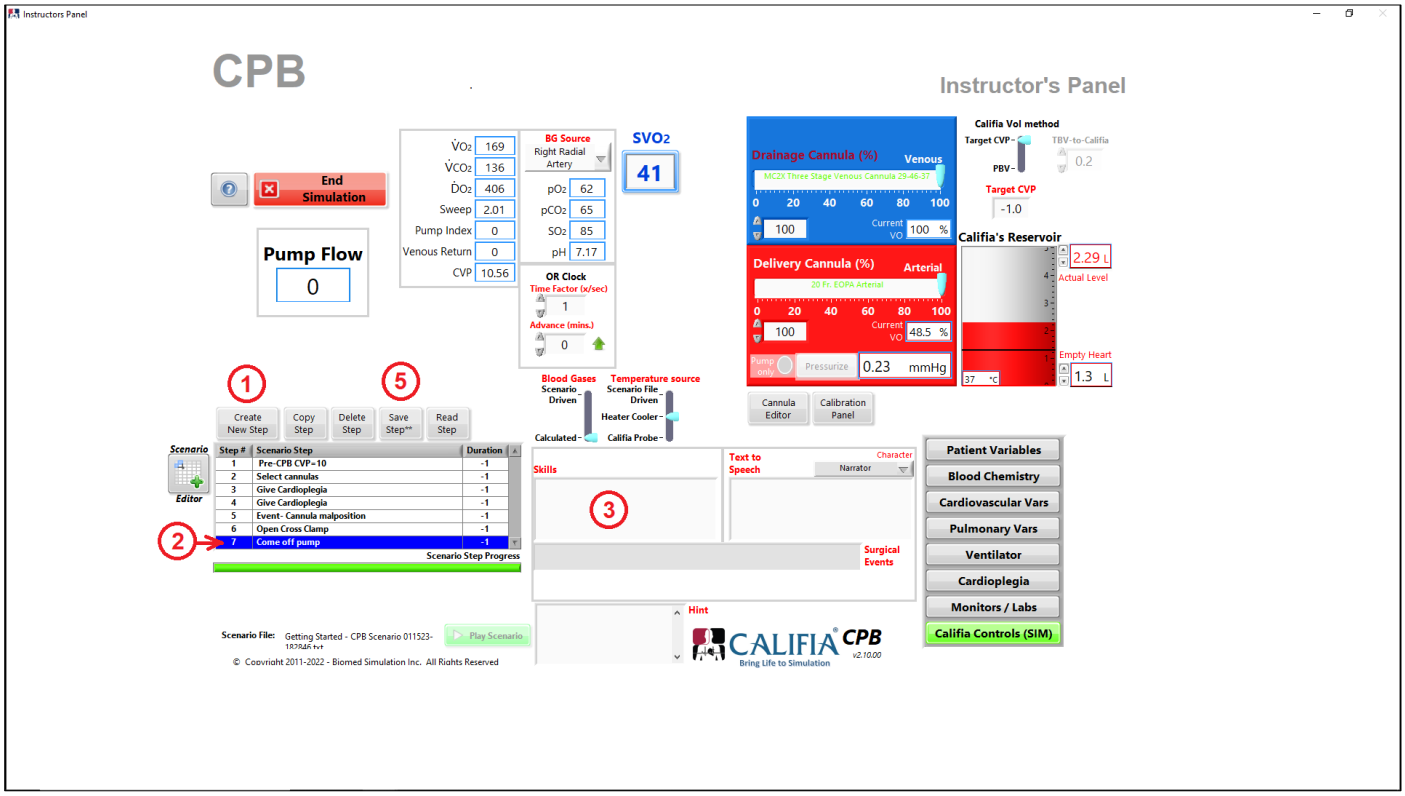

Figure 5.33 Step 7 edits

5.17.10 Run newly created scenario file

Follow these steps, refer to Figure 5.34,

① Press Step 1.

② Press **Read Step** to read first step in scenario file.

③ Use the **Play Scenario** button to play through the scenario file one step at a time.

Table 4.2 outlines the key actions by each player for each step: Instructor and Student.

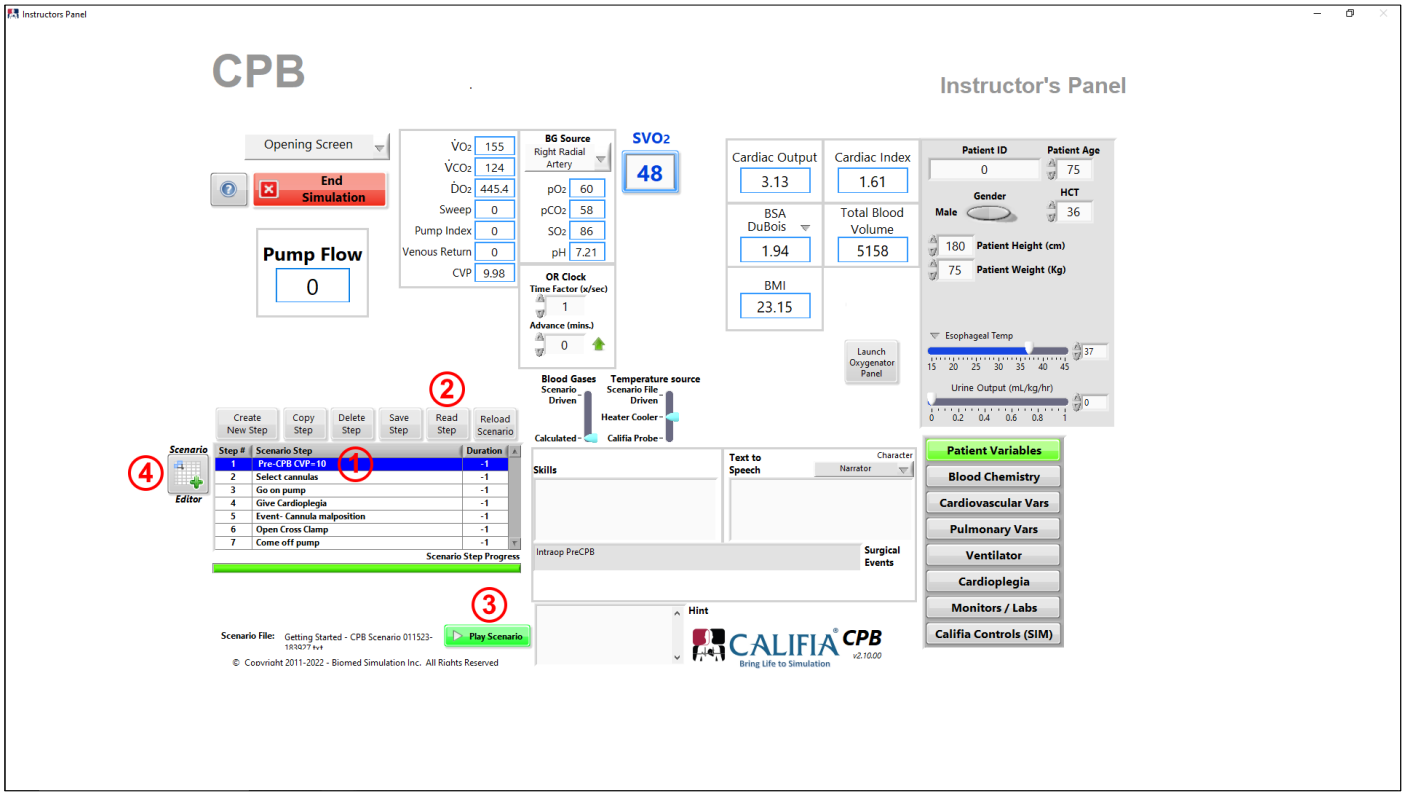

Figure 5.34 Run Scenario File

Step	Instructor	Student
1. Pre-CPB	*Review patient condition*	
2. Select Cannulas	*Review cannula selection*	
3. Go on pump	*Observe*	*Set gas blender, go on pump*
4. Give Cardioplegia	*Close Cross Clamp*	*Deliver CP*
5. Event: Cannula issue	*Observe*	*Identify issue*
6. Open Cross Clamp	*Open Cross Clamp*	*Observe patient vitals*
7. Come off pump	*Observe*	*Wean off pump*

Table 5.2 Actions by Instructor and Student when running this simulation scenario

5.17.11 Package scenario file as a SIM file

A SIM file is a convenient approach to package simulation cases. These can be shared and loaded in other computers running the Califia Simulator application.

A single file bundles the following files used in a simulation case:

6. Scenario file.
7. Ventilator.INI file.
8. Any media the scenario uses.
9. Any Lab Reports and TEG images.
10. Future files such as Drug definition files, additional forms (patient condition, history, etc) will be included.

To create a SIM file,

Press Scenario Editor button, ④, refer to Figure 5.34.

For the following steps, refer to Figure 5.35,

① Press **File** » **Create .SIM bundle.**

② Choose a target location for the SIM file; shown is the *Desktop*.

③ Press **Create** button to build SIM file.

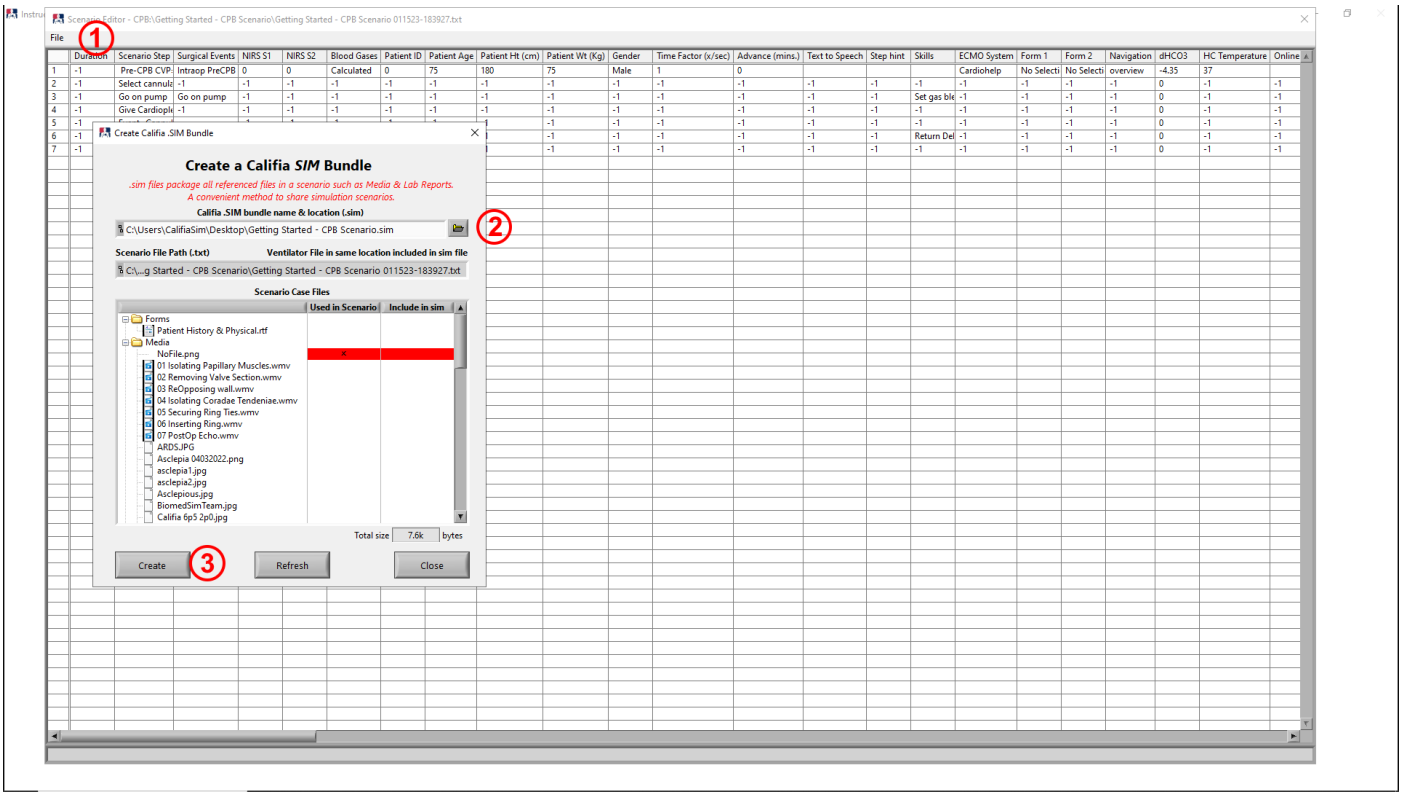

Figure 5.35 Create a SIM bundle

10.1.1 Steps to unbundle a SIM file

To unbundle a SIM file, refer to Figure 5.36,

① From Opening Screen, press **MENU** button then **Unbundle SIM** button.

② Select SIM file.

③ Press **Unbundle** button then **Close** to return to Opening Screen.

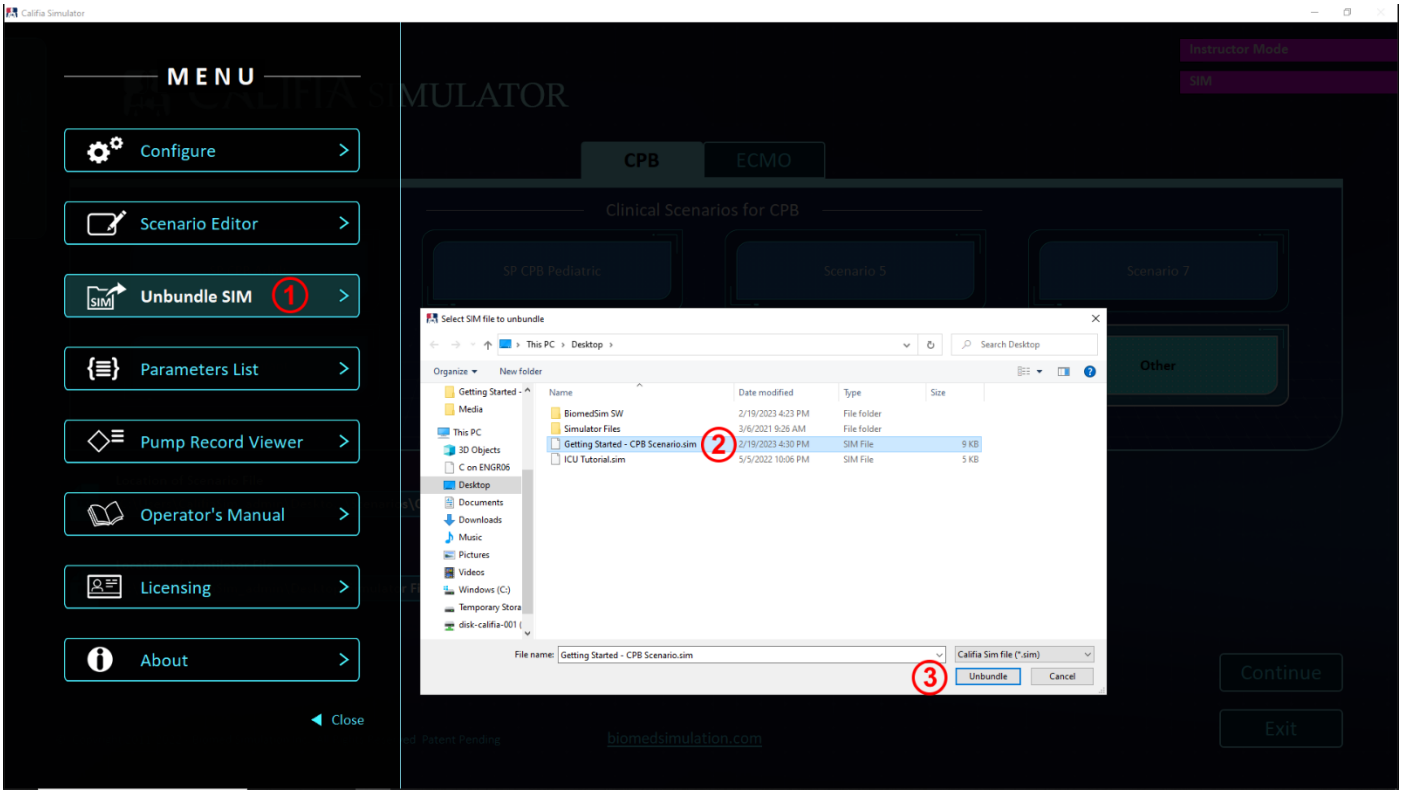

Figure 5.36 Unbundle a SIM file

When a SIM file is unbundled, in addition to placing all files in their proper locations, it configures the Califia Simulator application so it's ready to run the unbundled simulation scenario, refer to Figure 5.37.

① Scenario file and Ventilator.ini file paths are loaded.

② **Other** button is linked with scenario as defined in SIM bundle.

③ The simulation mode (**CPB** or **ECMO**) is selected.

④ The operator can press the **Continue** button to step into the simulation case.

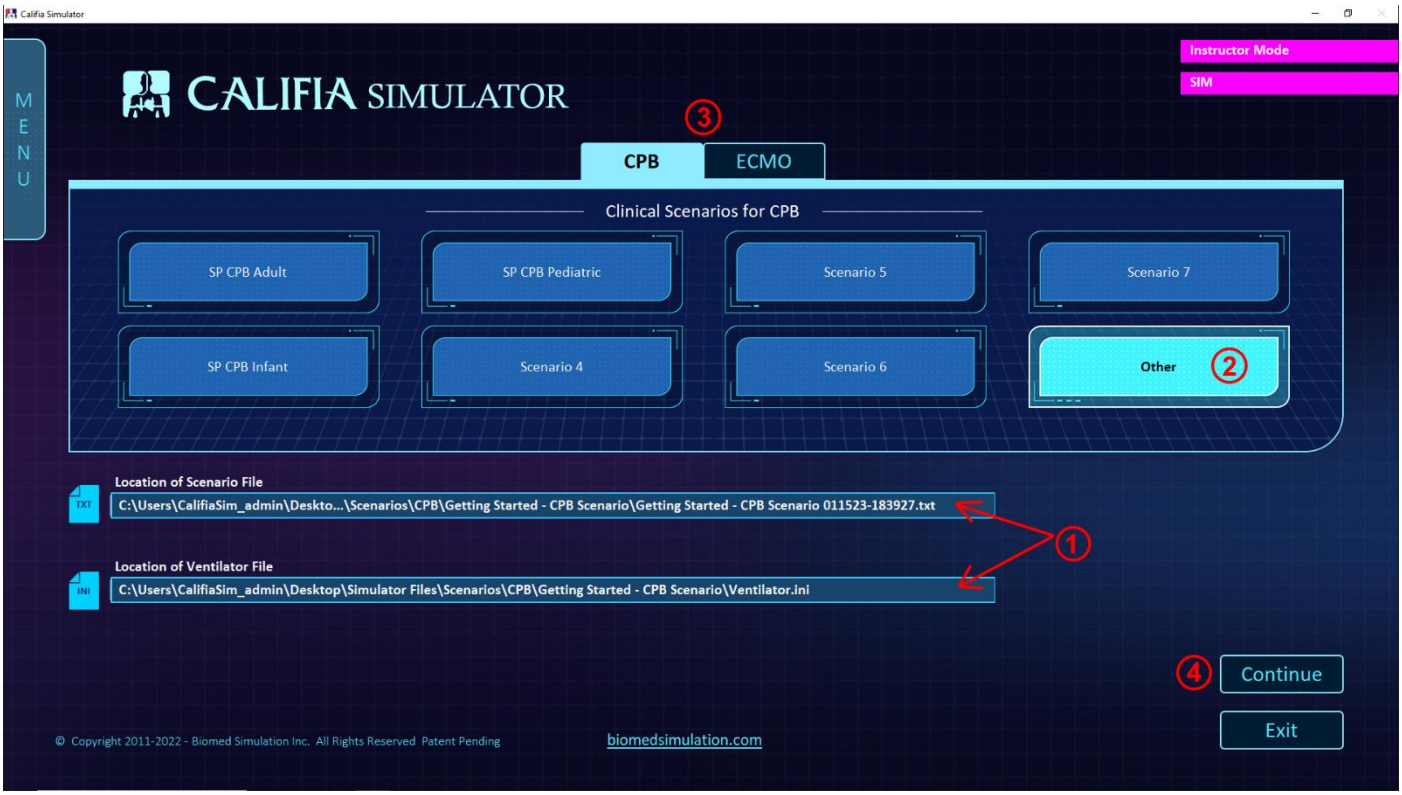

Figure 5.37 Results of unbundling SIM file

6

Let’s go on ECMO! – an ECMO simulation [SIM mode]

This chapter steps through an ECMO simulation. You can follow along.

Approximately 60 minutes to complete this chapter.

6.1 SIM mode only in this chapter

Refer to Figure 5.1 , ①.

SIM

Sections in this chapter headlined with this image refer to software-only simulation. No CPM or real pump is involved.

Chapter 5 introduces an ECMO simulation case using the CPM.

6.2 Use a Standardized Patient scenario

Select one of the six SP ECMO scenarios available, Figure 6.1, ②:

- SP VA ECMO Adult
- SP VA ECMO Infant
- SP VA ECMO Pediatric
- SP VV ECMO Adult
- SP VV ECMO Infant
- SP VV ECMO Pediatric

Press **Continue** button, ③, to step into the simulation.

Figure 6.1 Opening Screen » ECMO mode

6.3 ECMO – Instructor's Panel, Legacy Learner & 3D ICU

The Califia ECMO Simulation environment includes 3 main panels, refer to Figure 6.2. Minimize the Califia3D ICU window to show the Legacy Learner screen.

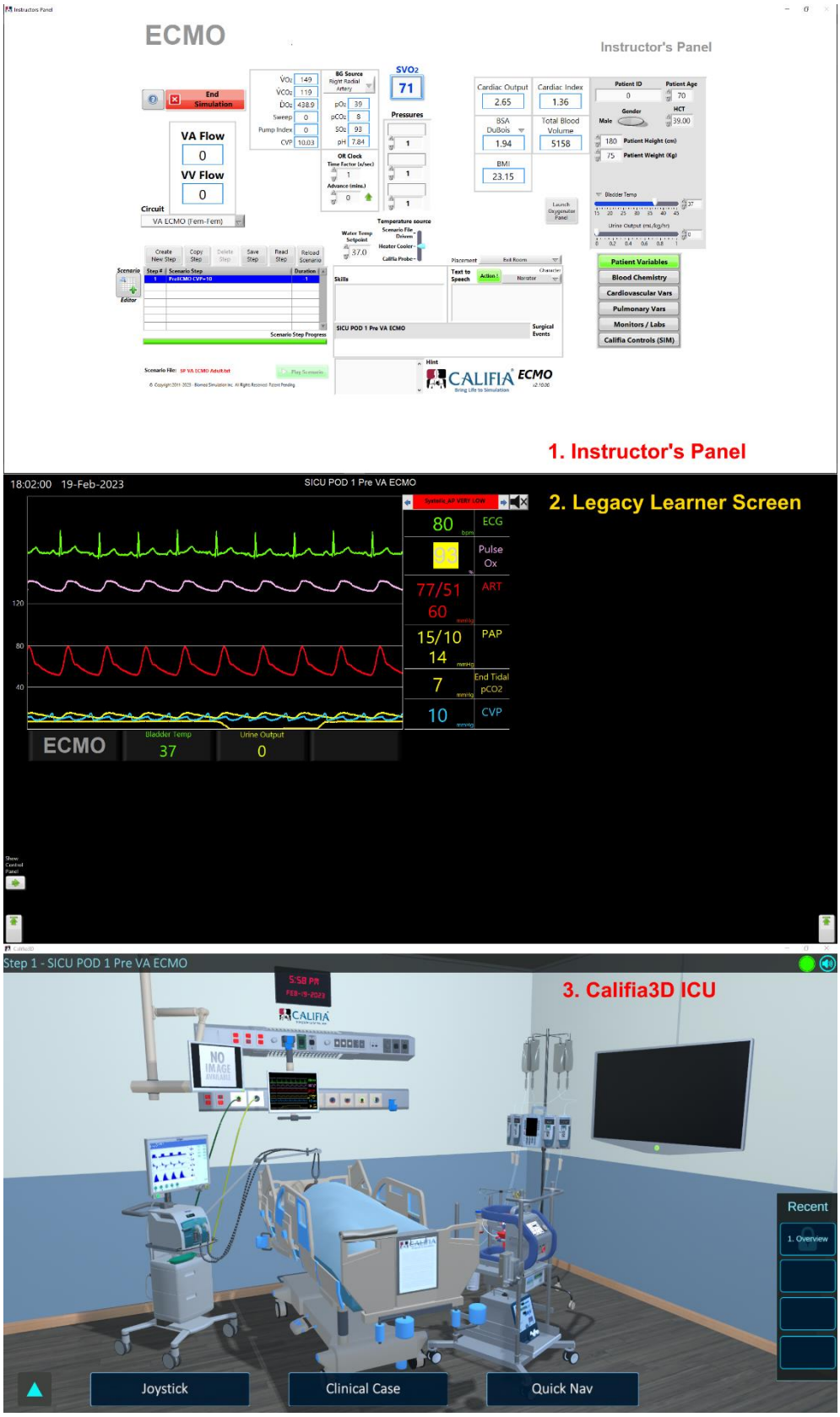

Figure 6.2 ECMO main environments

6.4 Patient Demographics

Refer to Figure 6.3, review and change the following:

① **Age**

② **HCT**

③ **Gender**

④ **Weight**

⑤ **Height**

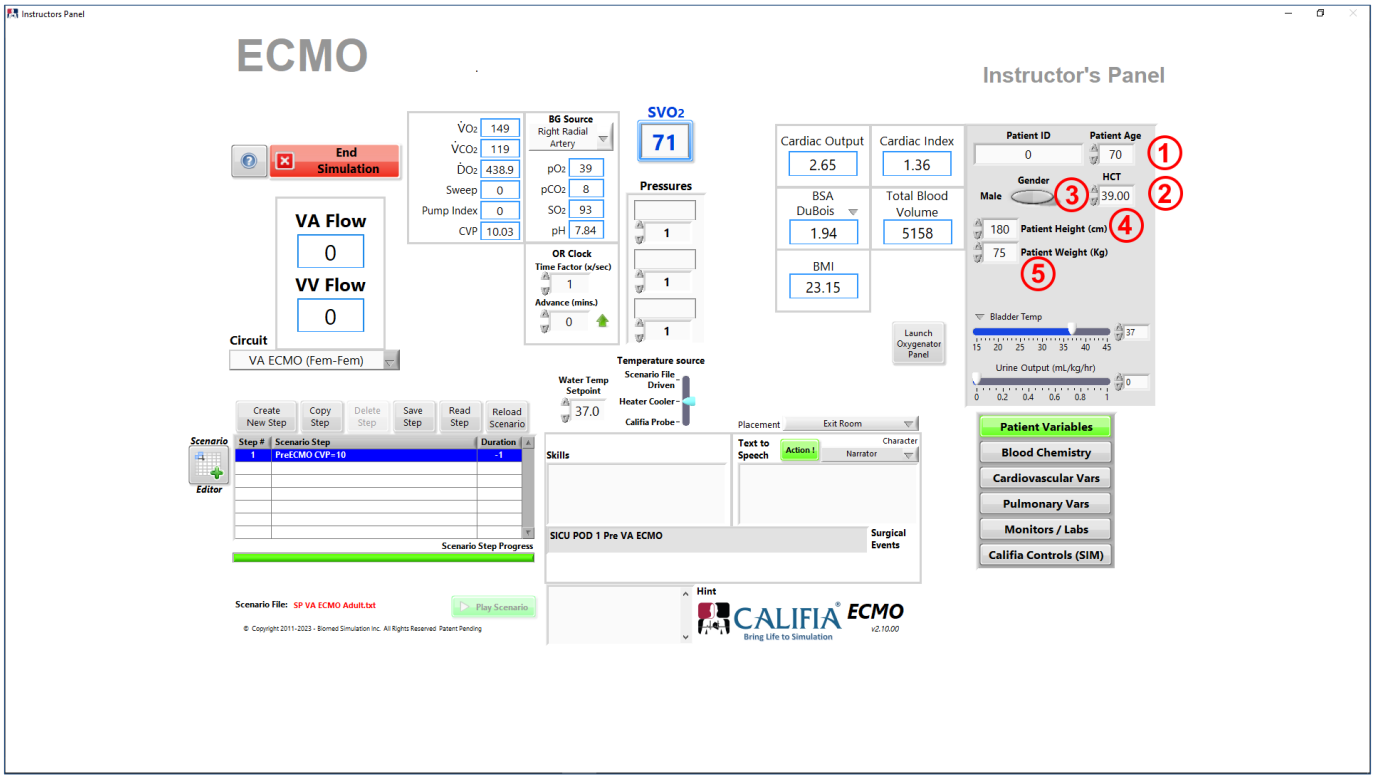

Figure 6.3 Patient demographics in Instructor's Panel

6.5 CVP Gain

In **Instructor's Panel,** press the **Calibration Panel** button under **Califia Controls** to bring up the **Califia Calibration Panel**, Figure 6.4. Set **CVP Gain** as dictated in Table 6.1.

BSA (m^2)	CVP Gain
< 1	3.5
Between 1 & 2	3.0
> 2	2.5

Table 6.1 BSA vs CVP Gain

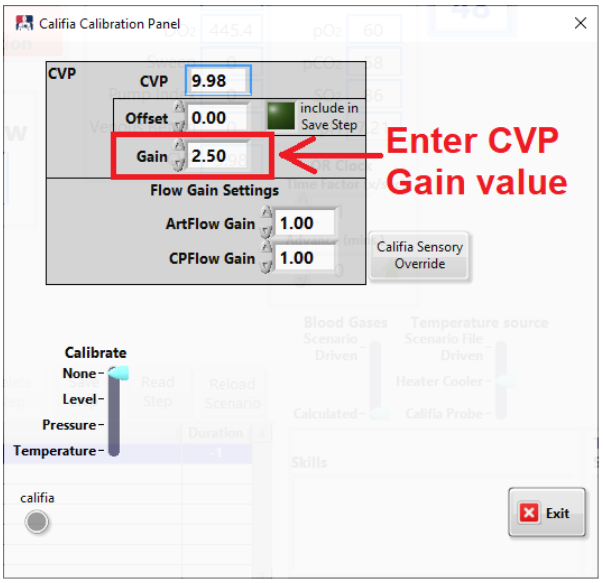

Figure 6.4 Califia Calibration Panel » CVP Gain

6.6 CVP

Set CVP to 10 mmHg

SIM

Refer to Figure 6.5, go to **Instructor's Panel » Califia Controls.**

① Enter **10** for **Target CVP** then press <*Enter*> .

② Volume in the virtual Califia's Reservoir changes until CVP reaches 10, ③.

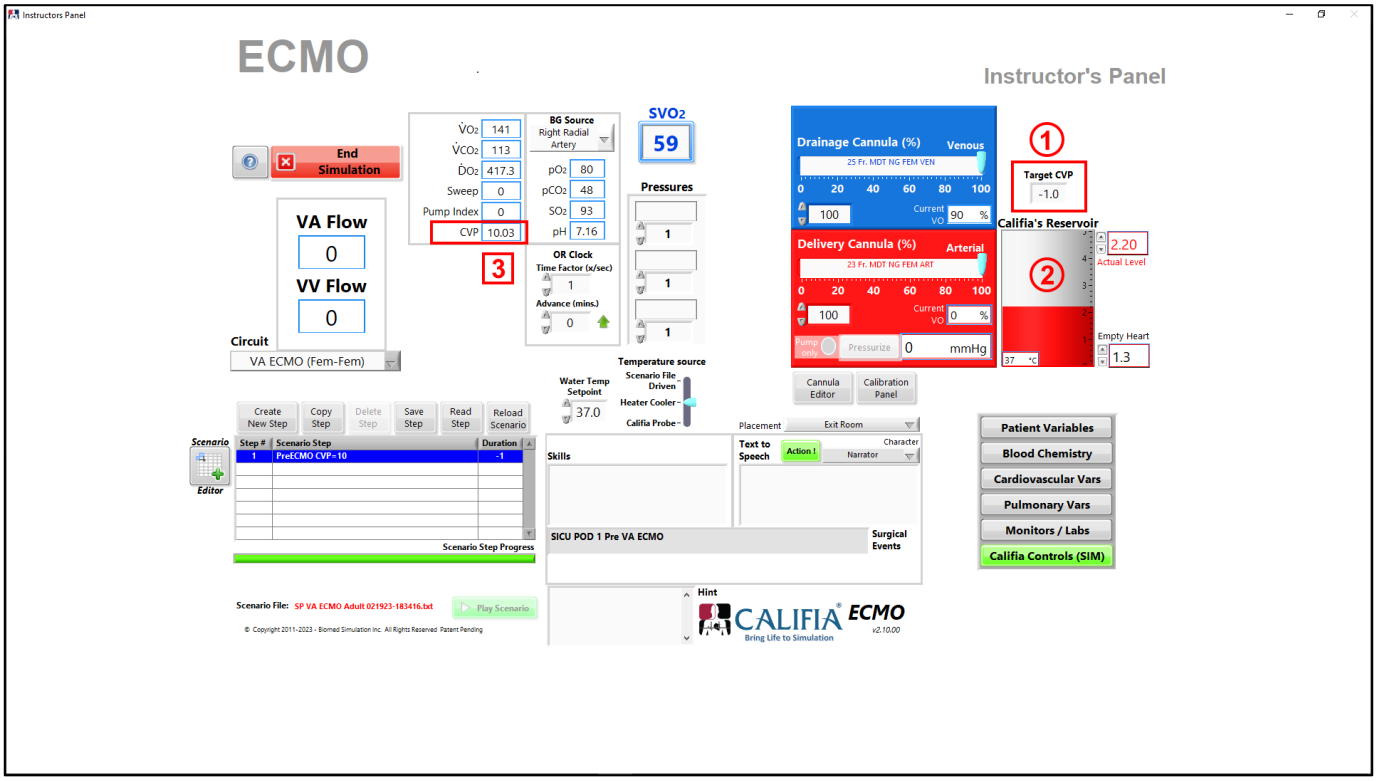

Figure 6.5 Set Target CVP in SIM mode

6.7 Arterial Pressure

Refer to Figure 6.6, in **Instructor's Panel** » **Cardiovascular Vars**,

① Press **Set Arterial Pressure** button.

② Specify desired **Systolic** and **Diastolic** Arterial Pressures in **Model Settings** panel.

③ Press **Target** button.

④ It takes a few seconds to find values for **LV Contractility** and **SVR**.

⑤ Once Targetting is complete, press **Save Step** to save all changes to scenario file.

⑥ Press **Confirm** button.

Close **Model Settings** panel upon saving changes to scenario file.

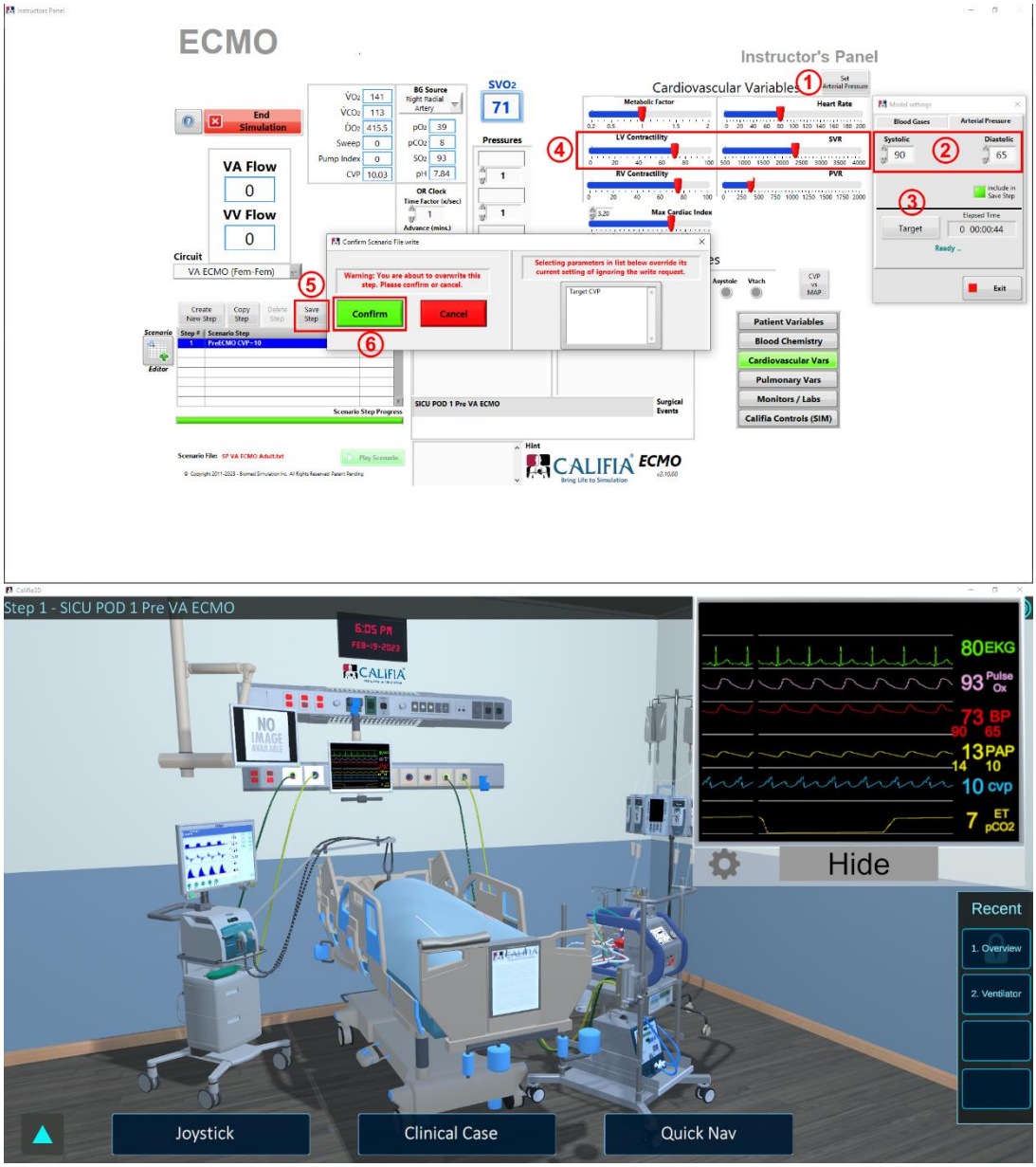

Figure 6.6 Set Systolic and Diastolic Arterial Pressure

6.8 Ventilator Settings

While referring to Figure 6.7, approach the **Ventilator** in the 3D ICU room by pressing on it. The buttons along the bottom left corner can be pressed to edit. Turn the knob in bottom right to change value, depress the knob to commit the value change:

① **FiO_2**

② **PIP**

③ **Rate**

④ **PEEP**

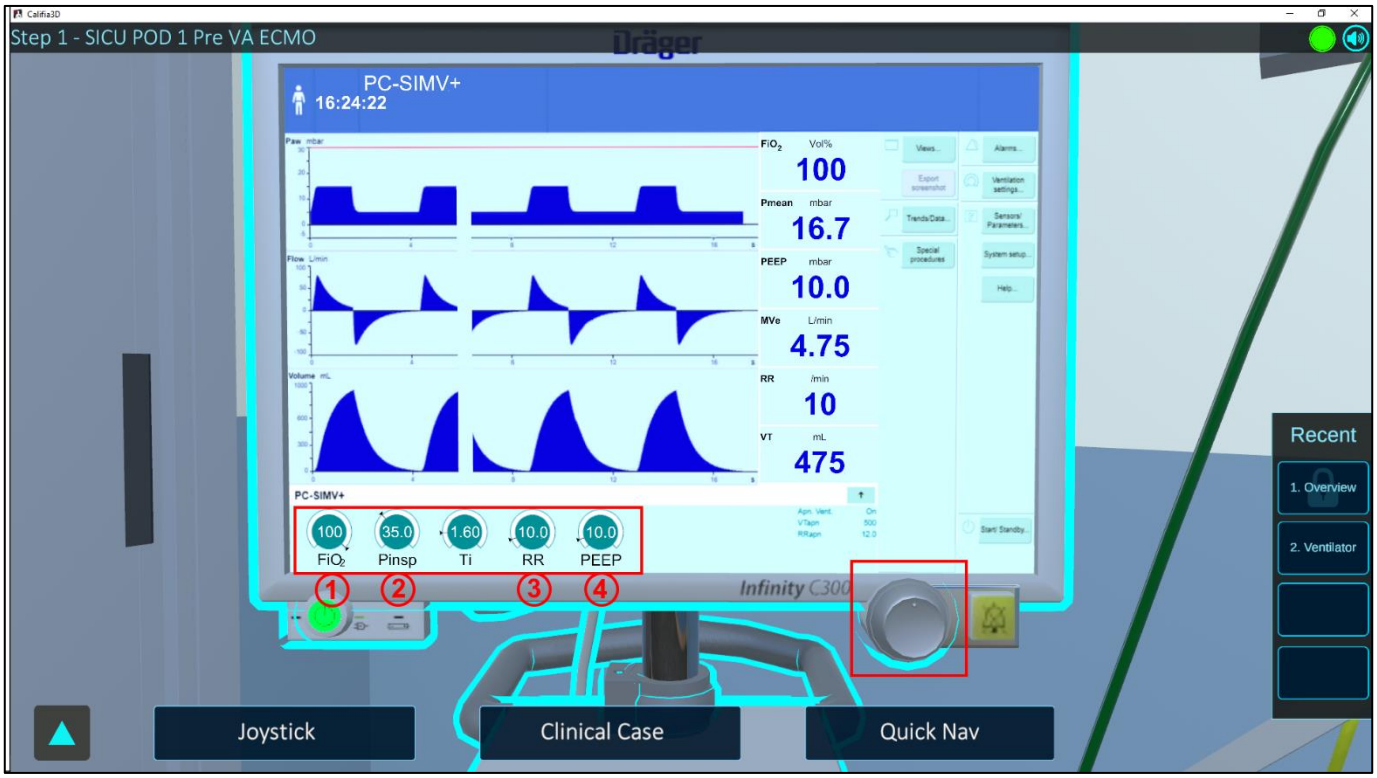

Figure 6.7 Ventilator settings

6.9 Blood Gases

6.9.1 Configure patient's arterial blood gases

Refer to Figure 6.8, go to **Instructor's Panel** » **Blood Chemistry**.

① Press **Calculate Desired Gases** button.

② Specify desired **pO2**, **pCO2** and **pH** for arterial blood in **Model Settings** panel.

③ Press **Target** button.

④ It takes several minutes to find values for **HCO3-**, **Dead Space** and **Pulmonary Shunt Fraction**, the first parameter is in the **Blood Chemistry** section.

⑤ Once Targetting is complete, press **Save Step** to save all changes to scenario file.

⑥ Press **Confirm** button.

Close **Model Settings** panel upon saving changes to scenario file.

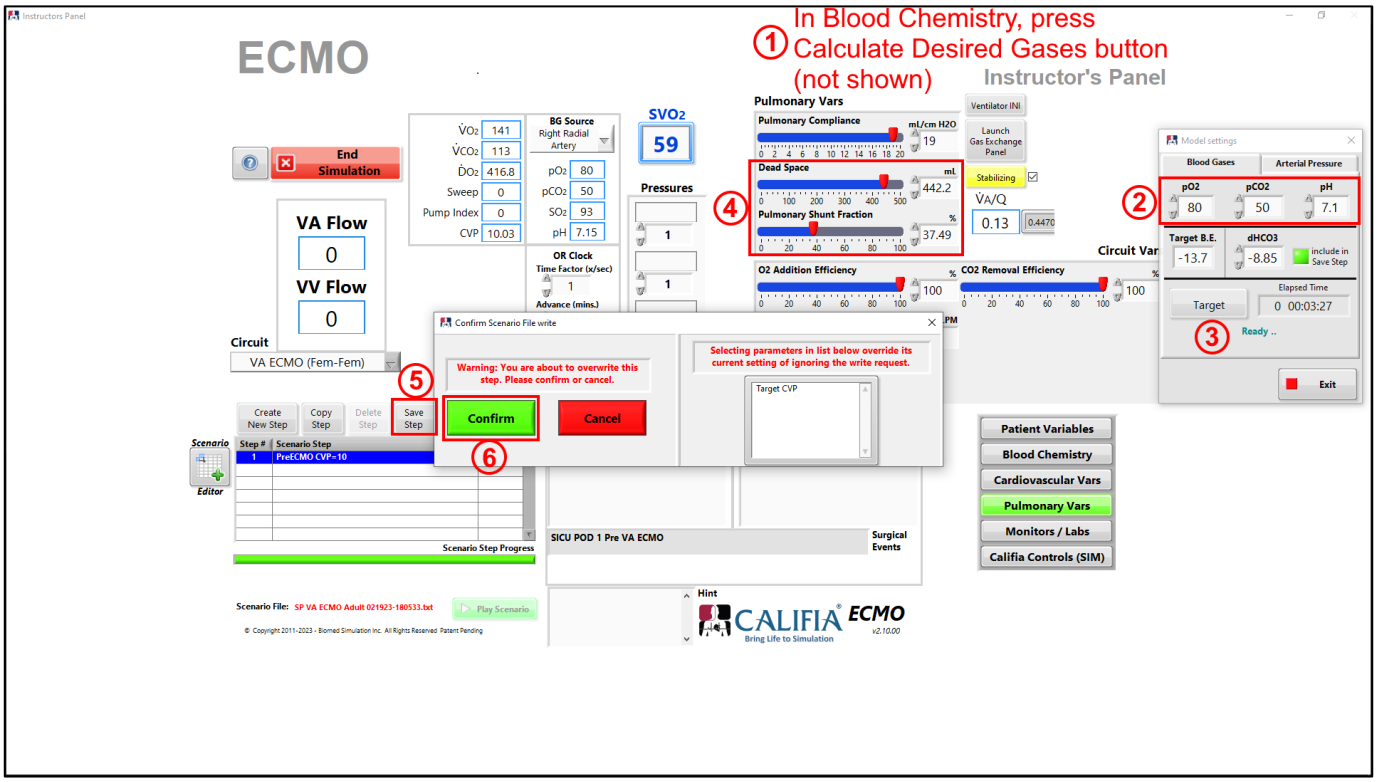

Figure 6.8 Set Blood Gases

6.9.2 In Califia3D, request an ABG (Arterial Blood Gases) lab from nurse

Follow steps shown in Figure 6.9 to have the nurse draw a blood sample:

① Bring up side menu.

② Press the phone button.

③ Select **NURSE1** from pager list and press **Call** button to summon nurse.

④ Select **Run GEM3000 Report** from list

Figure 6.9 Summon nurse to request ABG report

Referring to Figure 6.10, select a blood sampling site from selections, ①.

② Once the nurse leaves the ICU, press the clipboard at foot of bed to display blood gases report.

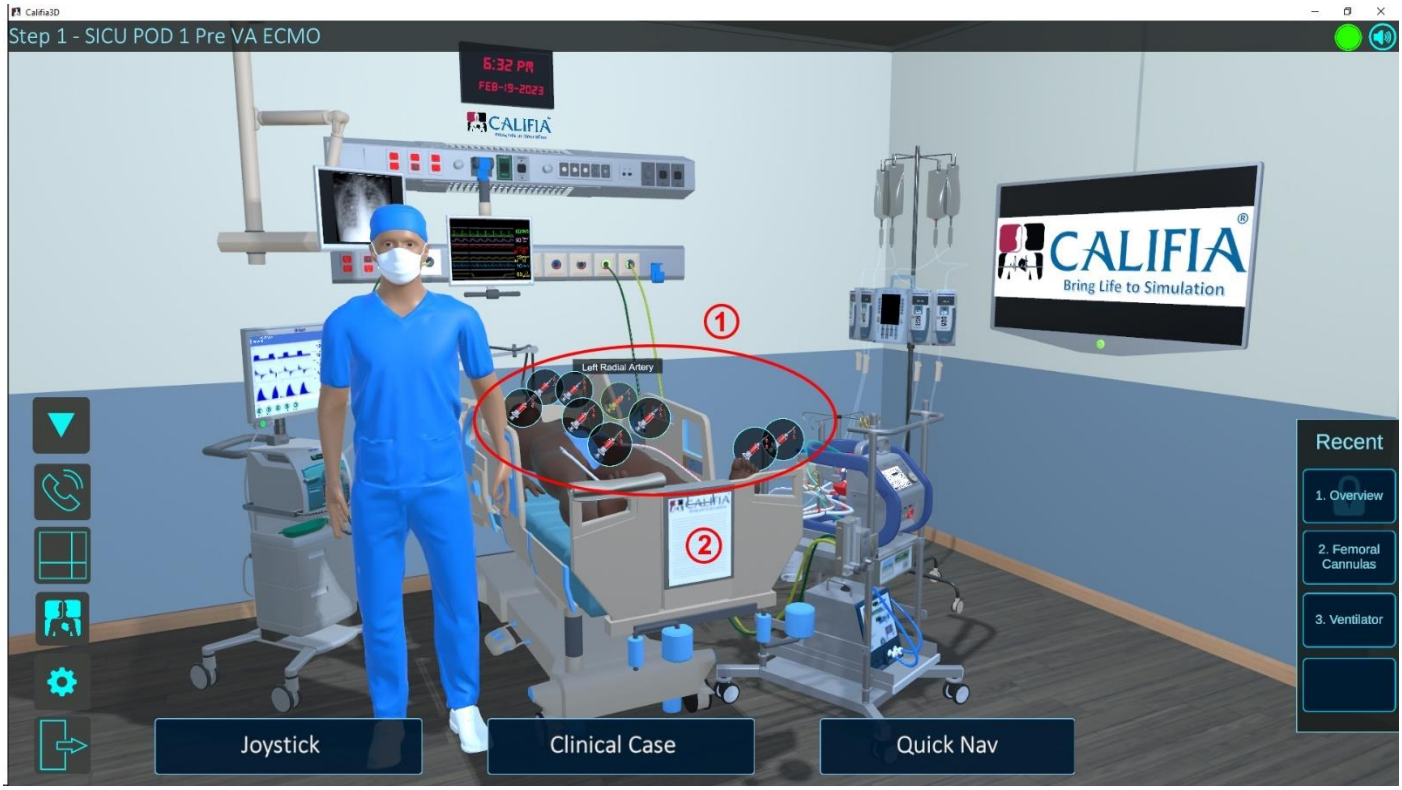

Figure 6.10 Select sampling site from options

Figure 6.11 shows the blood gases report. Click away from clipboard to put away.

Figure 6.11 Blood Gases report

6.10 Select Delivery and Drainage Cannulas for VA ECMO

In the Califia3D ICU space, approach the femoral cannulas, Figure 6.12.

Press rolled bedsheet at bottom of bed to cover or uncover patient.

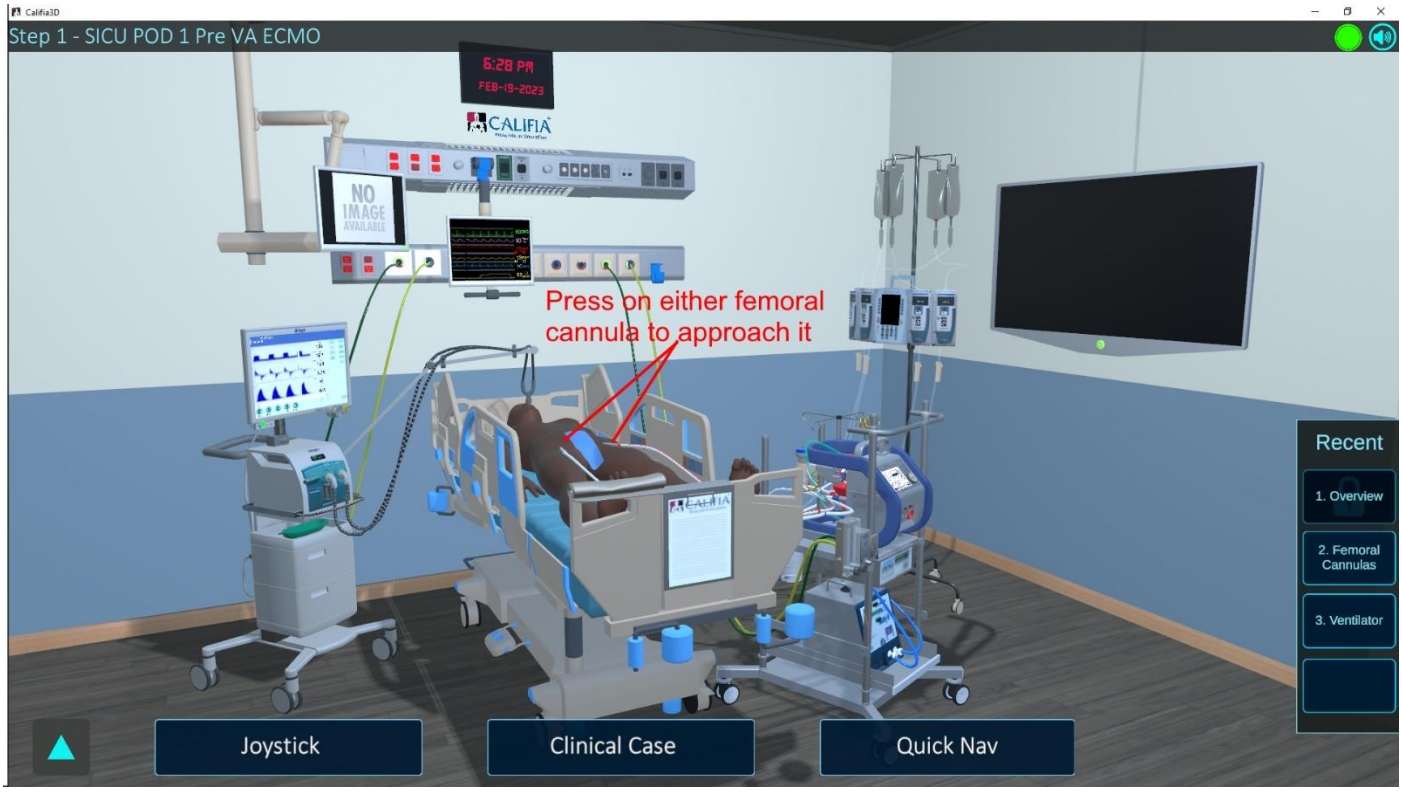

Figure 6.12 Patient's femoral cannulas

As shown in Figure 6.13:

① Press on the Left Femoral Arterial Cannula.

② Press **Change Cannula** to bring selection list.

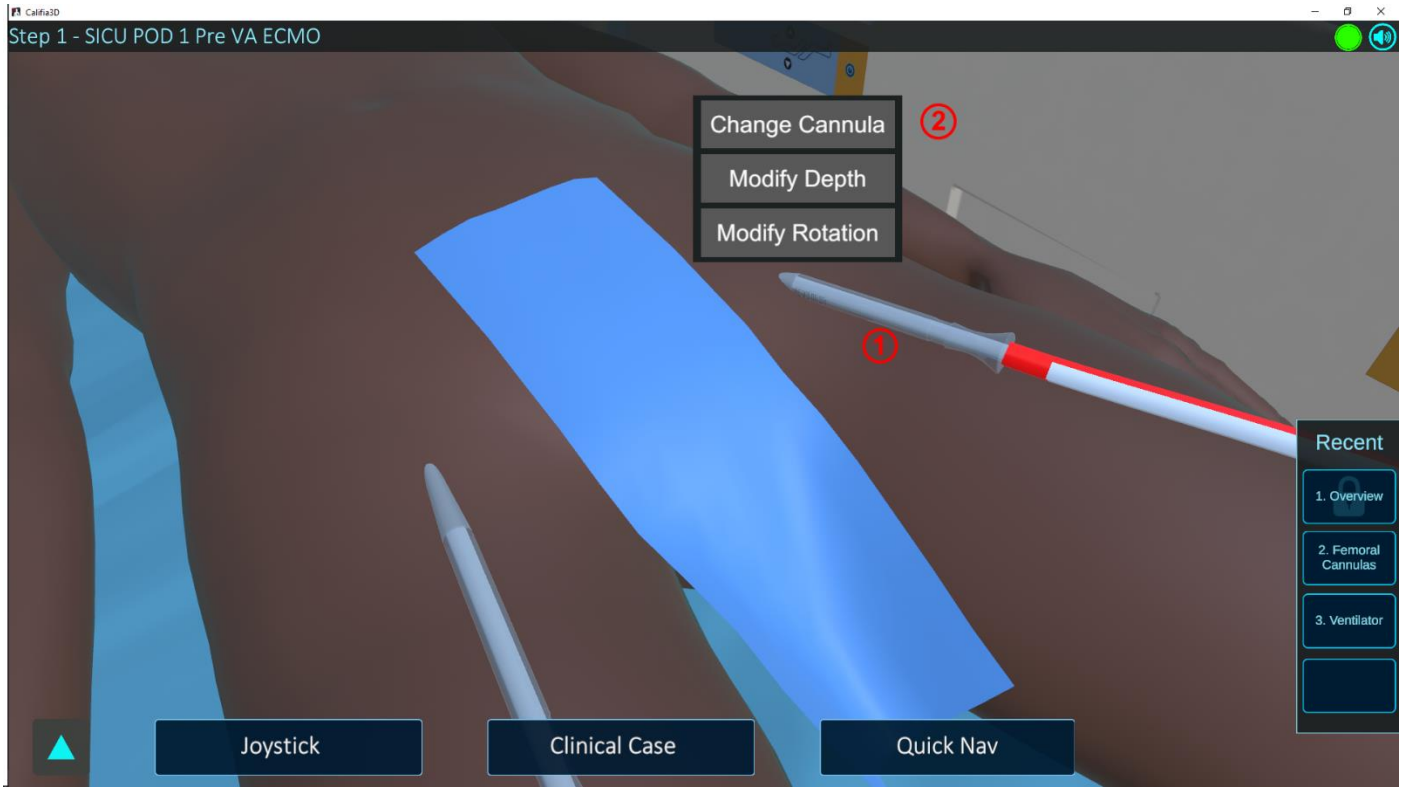

Figure 6.13 Bring up Change Cannula dialog

As shown in Figure 6.14:

① Select an appropriate cannula from list.

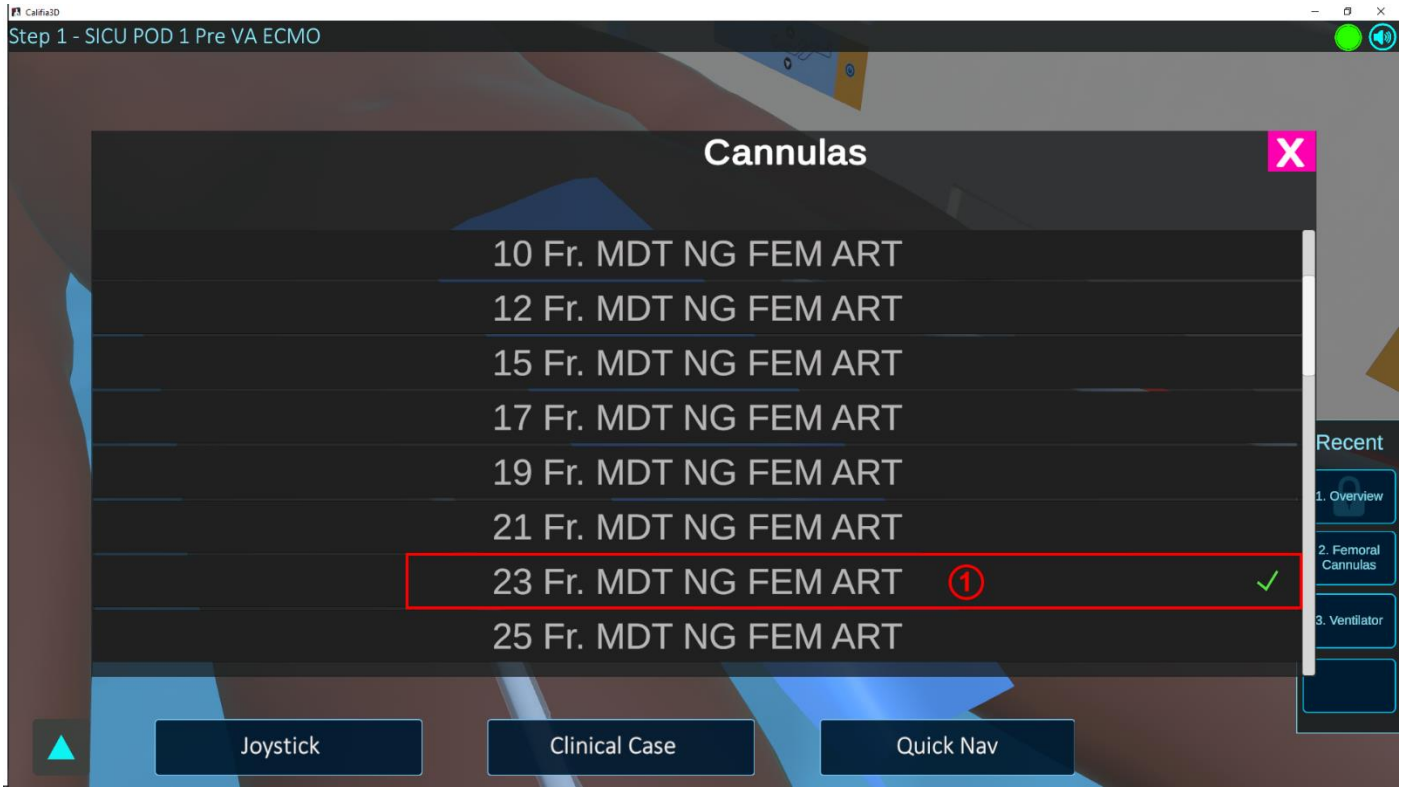

Figure 6.14 Femoral Artery Cannula selection list

Pressure-Flow profiles for cannulas are modeled using respective electro-mechanical valves in CPM. The same performance profiles are used in SIM mode.

6.11 Set Gas Blender

Locate Gas Blender in Califia3D ICU, mounted on the ECMO cart, press it to approach it, Figure 6.15.

① Turn knob to set **Gas Sweep** to about *2 LPM*.

② Turn **FiO_2** knob to *100%*.

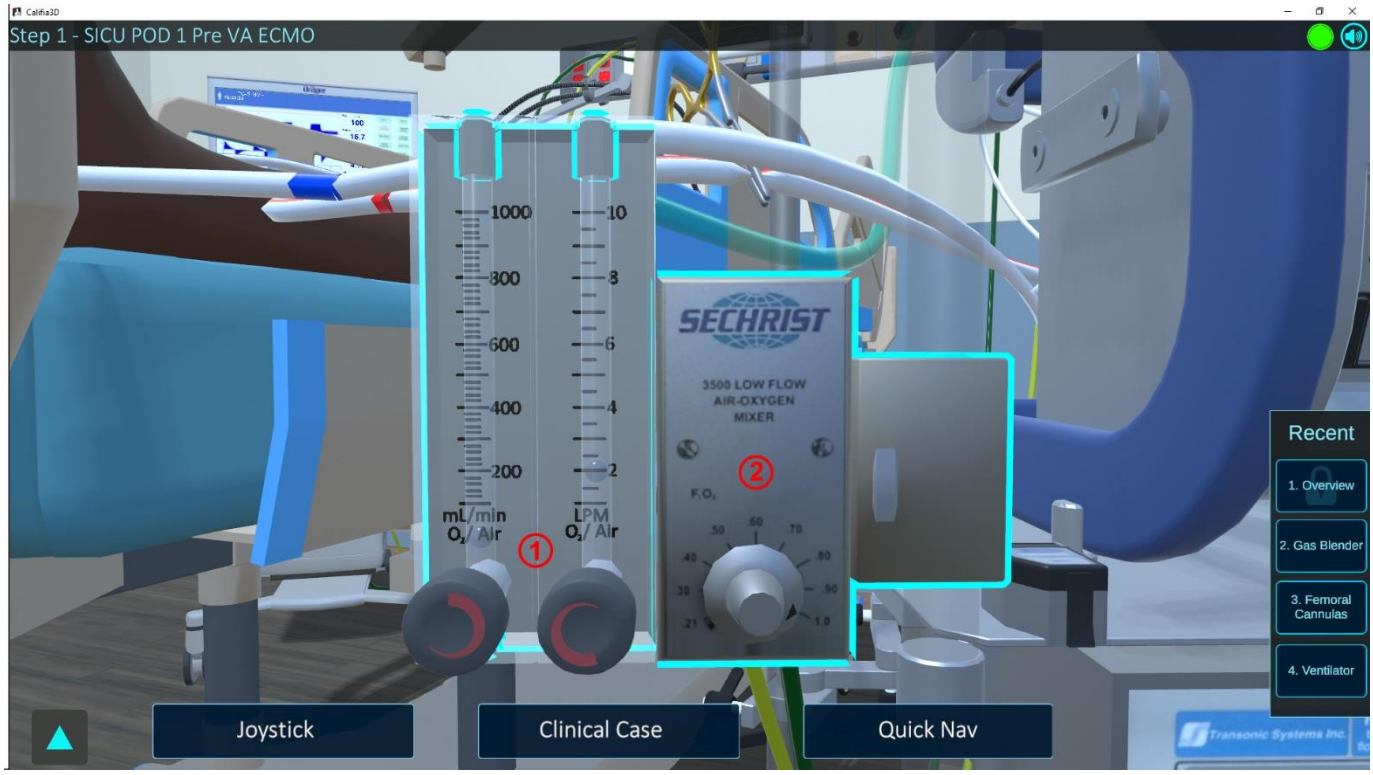

Figure 6.15 Set Gas Blender

6.12 Let's go on ECMO!

Refer to Figure 6.16, turn RPM knob in Cardiohelp until it reaches about 2000 RPM, ①.

② Clamp is in place in arterial line.

③ Pressing the Vitals Signs monitor can anchor it along top right of window.

Since this is a femorally cannulated VA ECMO configuration, as long as the pump outflow pressure is reasonably higher than the patient's heart mean arterial pressure, there should be forward flow once the clamp is removed.

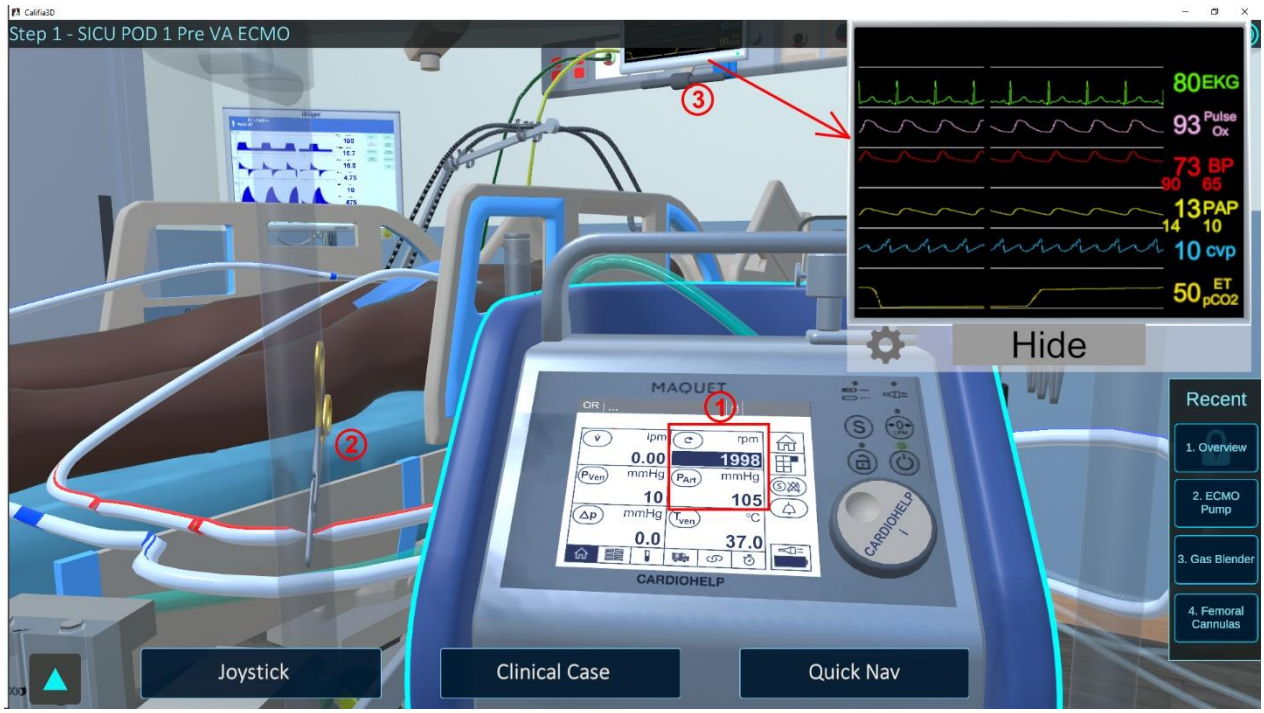

Figure 6.16 Pressurize circuit to ensure forward flow

Time to remove clamp, Figure 6.17, by pressing it. After a few seconds, flow will settle. In our case, flow is 1.73 LPM.

Key observations:

- Outflow blood color is brighter than inflow due to oxygenation effect.
- Pressure drop across oxygenator is 5.2 mmHg, which calculates to 3 mmHg/LPM.
- There remain some pulsatility in the arterial pressure waveform, signifying the native heart continues to eject blood.

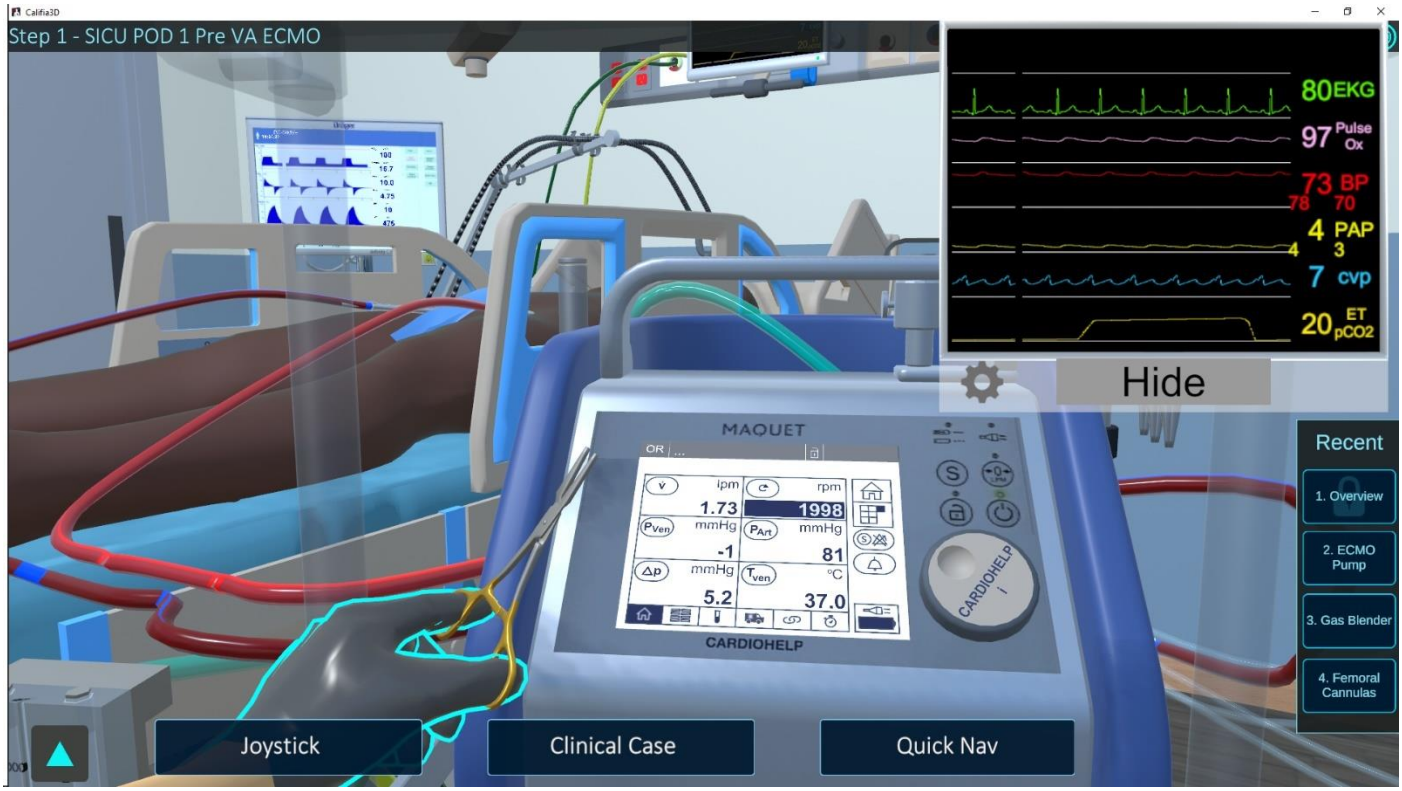

Figure 6.17 Forward flow after removing clamp

Referring to Figure 6.18, increase **RPM** to *3000*, ①. Also, set the **Oxygenator Pressure Drop** to *10 mmHg/LPM*, ②.

Key observations:

- Flow rate is now about *4.2 LPM*.
- Native heart is not longer ejecting; arterial pressure waveform is flat.
- Arterial pCO_2 is very high, ③.

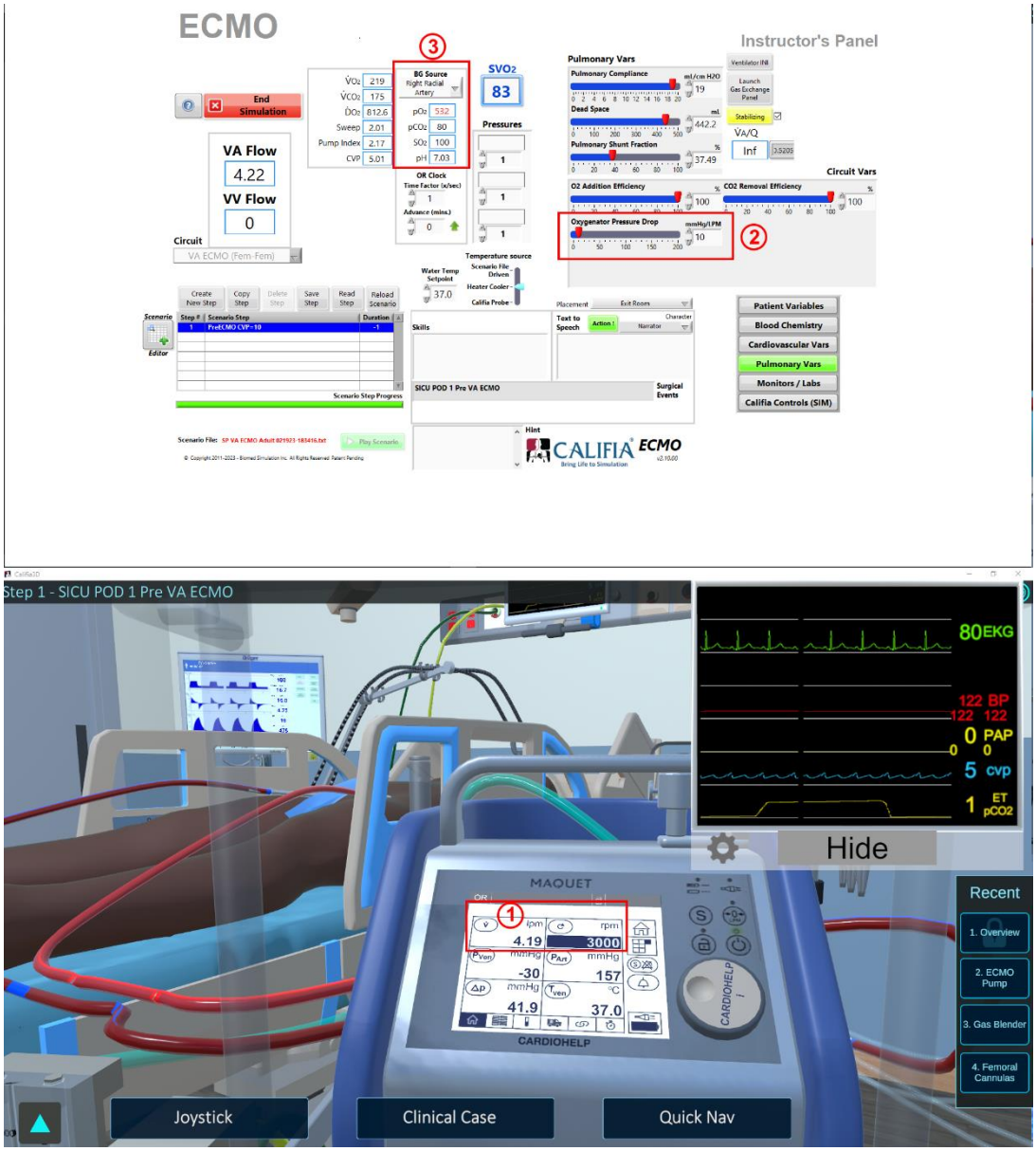

Figure 6.18 High flow at high RPM

Referring to Figure 6.19, the high arterial pCO_2 pressure is addressed by increasing Gas Sweep to about *4 LPM*, ①, resulting in pCO_2 in the mid 40s, ②.

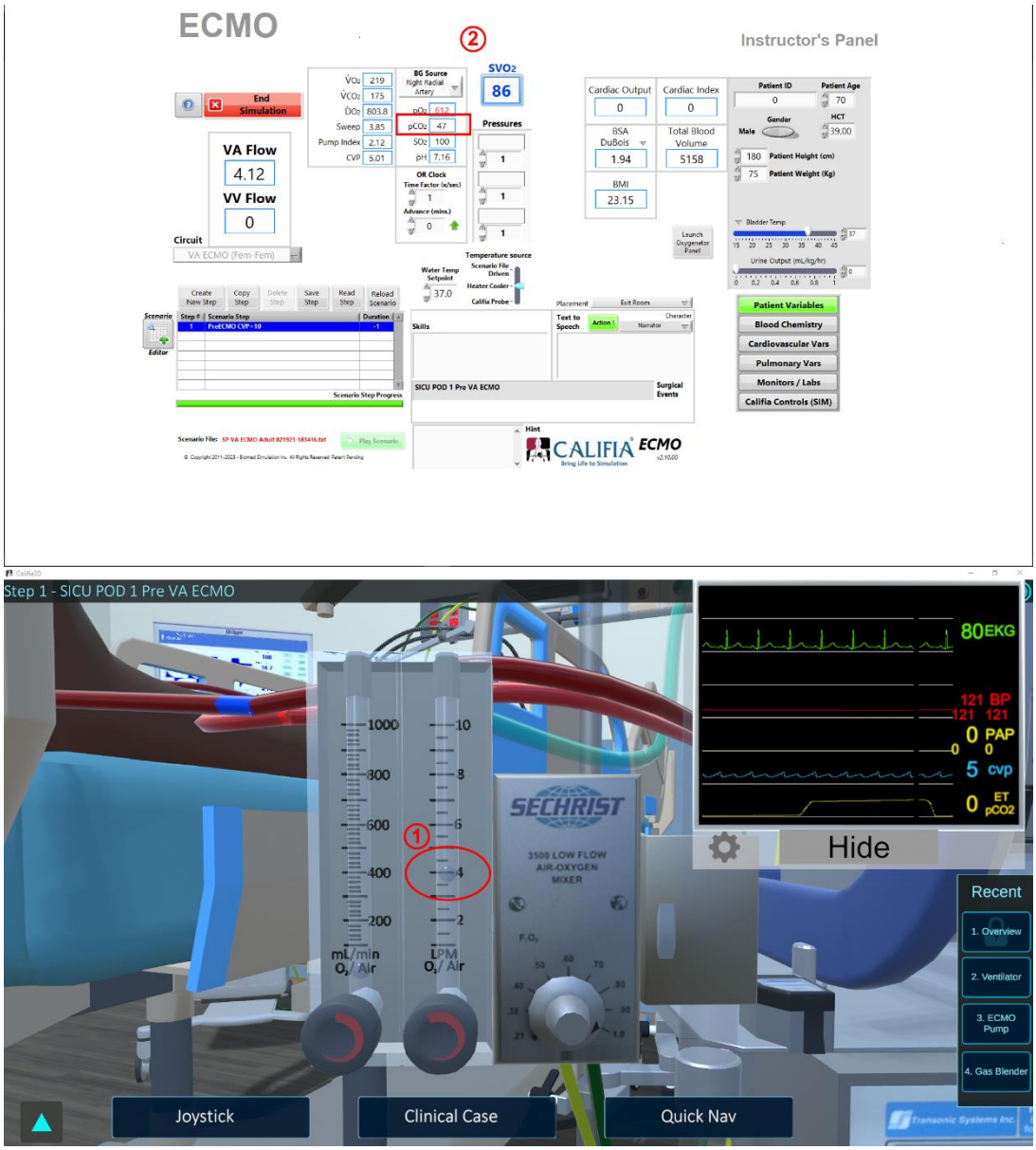

Figure 6.19 Higher gas sweep lowers arterial pCO_2

6.13 Event: Large pressure drop across oxygenator

Refer to Figure 6.20, in **Instructor's Panel » Pulmonary Vars**,

① Set **Oxygenator Pressure Drop** slider to about *70 mmHg/LPM*.

② Observe the drop in flow rate and large **ΔP** across oxygenator.

③ Arterial pressure shows a small Systolic-Diastolic range indicating the heart is able to eject.

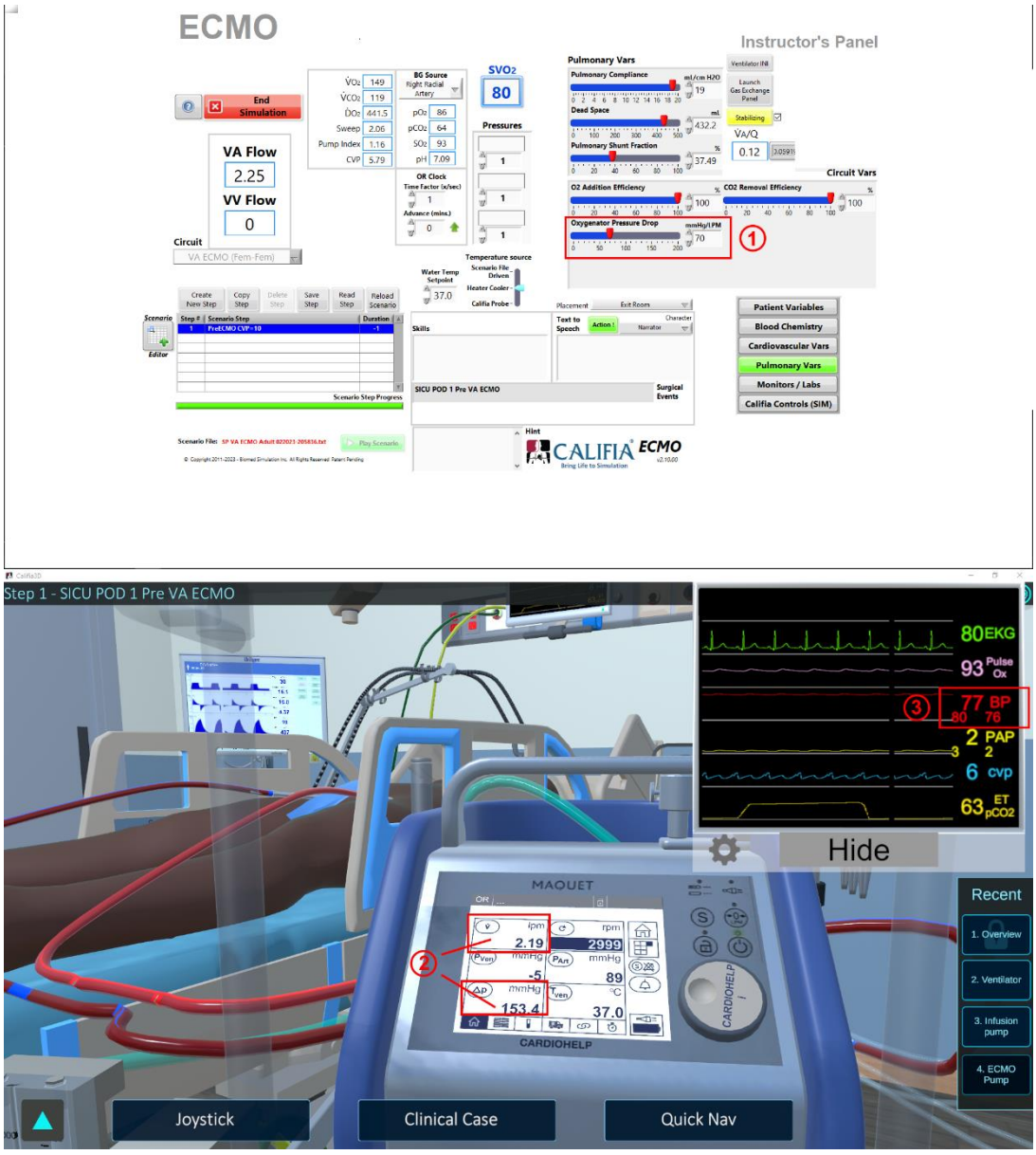

Figure 6.20 Effect of large pressure drop across oxygenator

If an Oxygenator change out is decided, then return **Oxygenator Pressure Drop** to something like *15 mmHg/LPM*, refer to Figure 6.21.

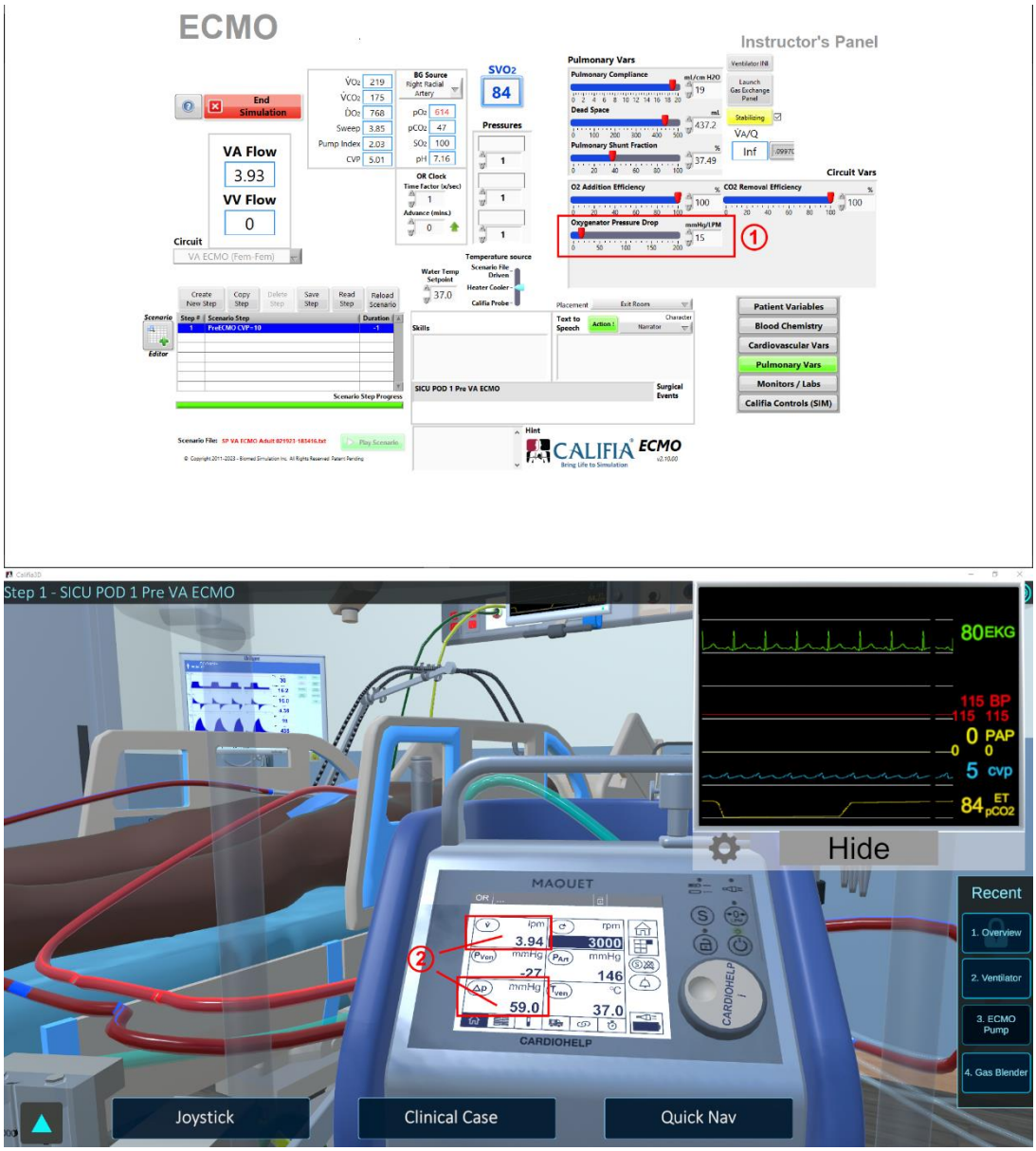

Figure 6.21 Result of Oxygenator change out

6.14 Return to Opening Screen

Refer to Figure 6.22, press **End Simulation** button, confirm request to return to **Opening Screen**.

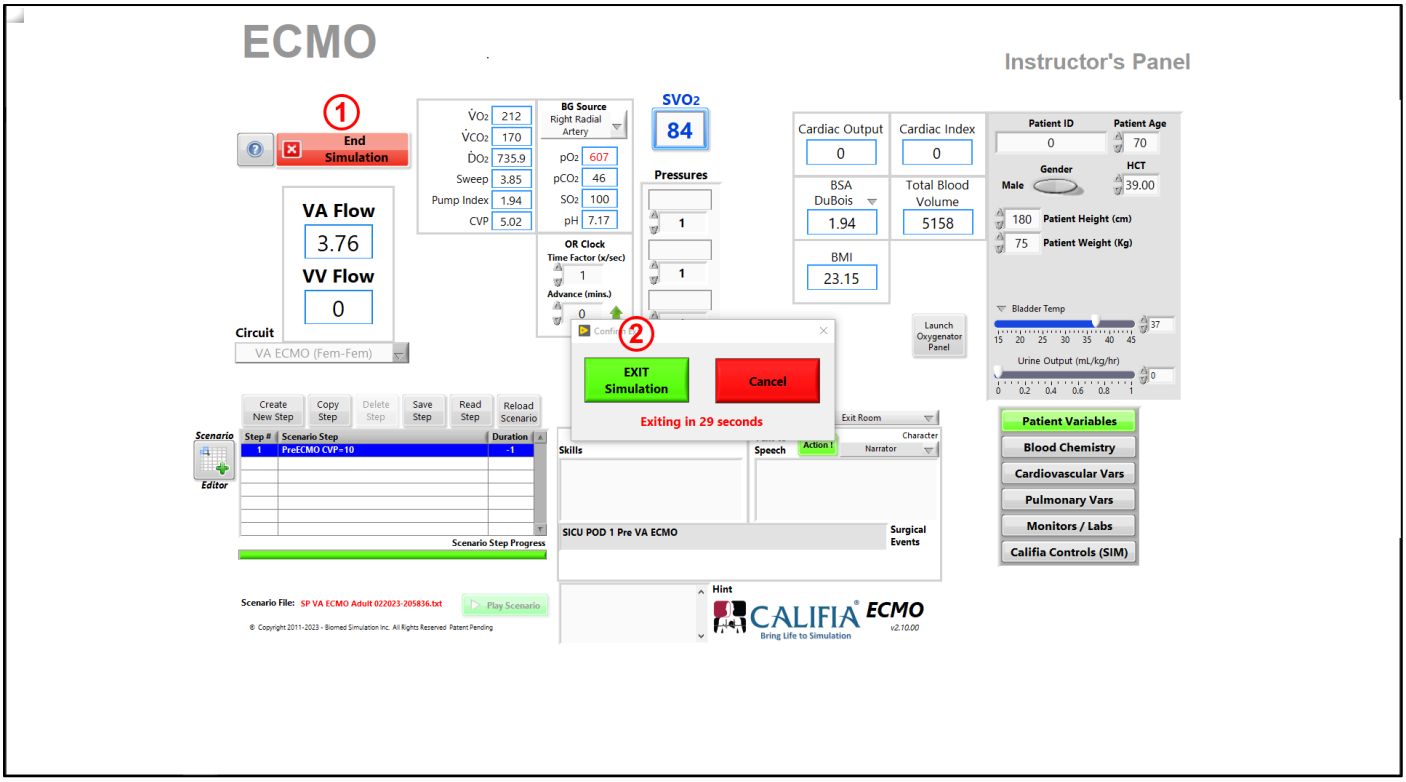

Figure 6.22 End Simulation

6.15 Create an ECMO Simulation Scenario File

In this section, we will repeat the ECMO case presented in this chapter however we will save all stages into a scenario file.

6.15.1 Access Scenario Editor

Refer to Figure 6.23, Press **MENU** button, ①, followed by **Scenario Editor** button, ②.

Figure 6.23 Access MENU in Opening Screen then Scenario Editor

6.15.2 Save Scenario File

Refer to Figure 6.24, in **Scenario Editor**,

① Press **File** menu selection

② Select **Save As….**

③ Enter a new scenario file name such as *Getting Started – ECMO*

This name is used to create a folder which will host the scenario file and ventilator.ini file

④ Set the **Button Selector** to **Button 7** and provide button with a label such as *Getting Started with ECMO*

⑤ Press the **Create** button to complete the new scenario file creation

Notice the **Scenario Editor** title reflects the new folder location and file name

⑥ Once new scenario file and folder created, return to **File** menu and press **Close**

Press **Close** button to close the **MENU** bar, this step is not shown.

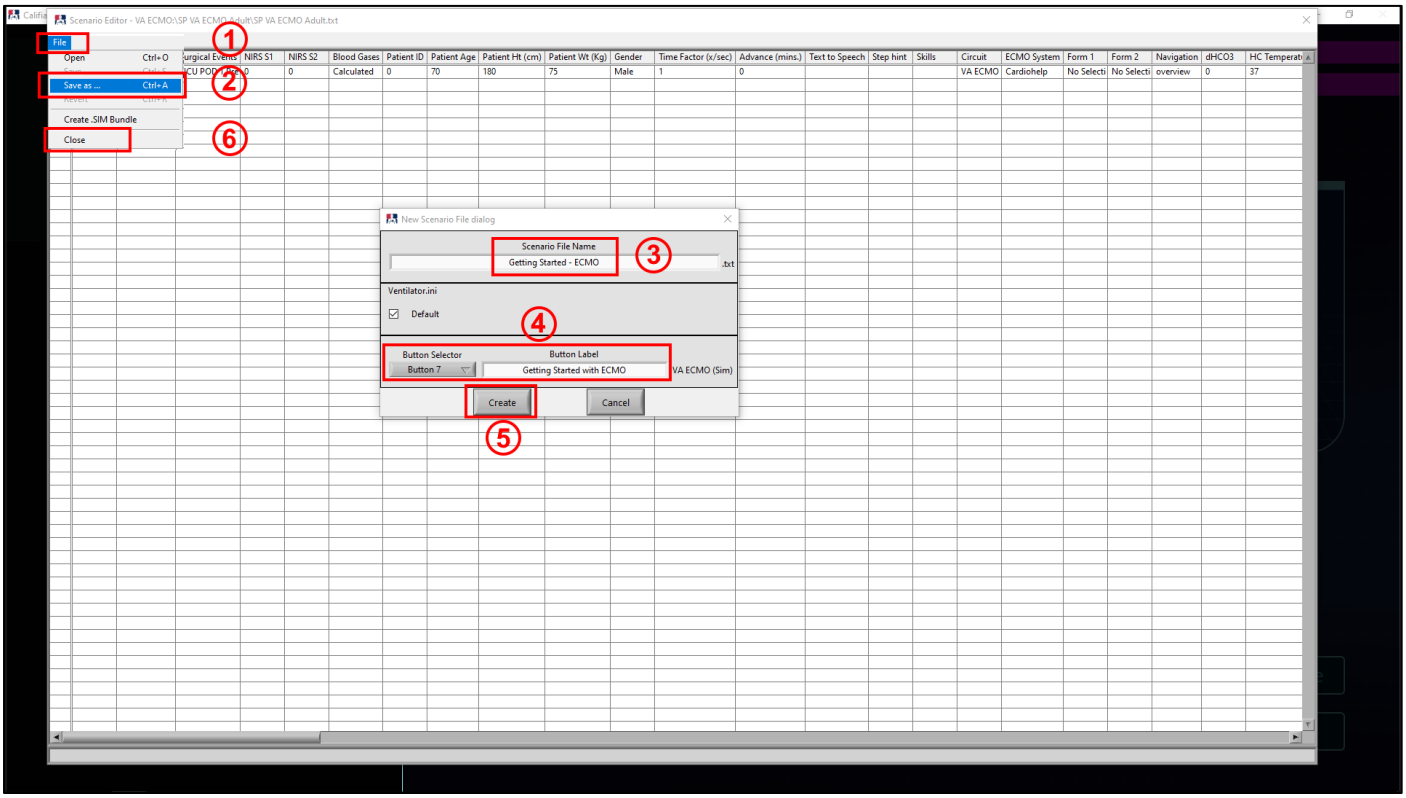

Figure 6.24 Save As... in Scenario Editor

6.15.3 New scenario file in Opening Screen

Refer to Figure 6.25:

① **Location of Scenario File** points to the newly created Scenario File

② The selected button is **Button 7** shown with label **Getting Started with ECMO**

③ Press **Continue** button to load new scenario file

Figure 6.25 Opening Screen New Scenario File

6.15.4 Scenario File Step 1 edits

The original scenario file was last saved with patient's arterial pressure and blood gases configured, Sections 5.7 and 5.9 respectively.

Ventilator settings are not scenario file parameters however initial values for **FiO2**, **PIP**, **Rate** and **PEEP** are stored in a file labeled ventilator.ini. To edit these initial values go to **Instructor's Panel** » **Pulmonary Vars** and press **Ventilator.ini** button, refer to Figure 6.26.

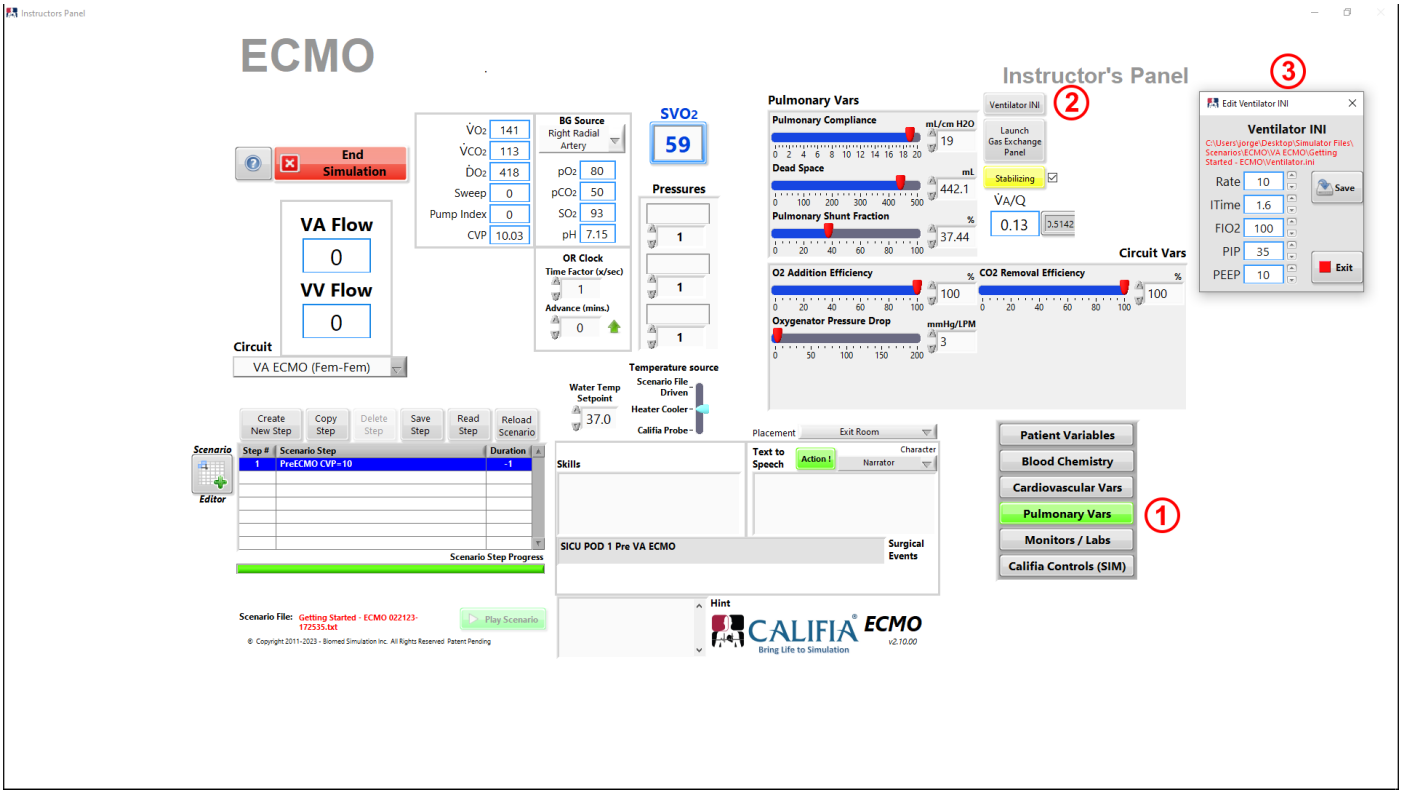

Figure 6.26 Edit Ventilator.ini parameters

Refer to Figure 6.27,

Media files can be setup to display in the two monitors in the Califia3D ICU environment.

① Go to **Monitors / Labs**.

② In the **Media** tab, choose media file from dropdown list and **Play** button set to green. Similarly, in the **TV** tab, select media file from list and set **Play** button to green.

③&④ Media file displays in ceiling-mounted screen and large TV displays media file in TV tab.

Skills field in **Instructor's Panel** is used by Instructor for key notes pertaining to the step they're added in.

⑤ Add following note in **Skills** field: ***Check ventilator initial settings. Set Media files. Use Text to Speech to help navigate the 3D environment.***

Text to Speech field in **Instructor's Panel** is helpful to help navigate the Califia3D ICU environment.

⑥ Add following in **Text to Speech** field: ***Press on the ventilator in the ICU room to review its settings.***

Finally, save all edits in Step 1,

⑦ Press **Save Step** button.

⑧ Press **Confirm** button to save selected step changes to scenario file.

Original scenario file is not overwritten. A new one is created in the same work folder; its filename includes a timestamp.

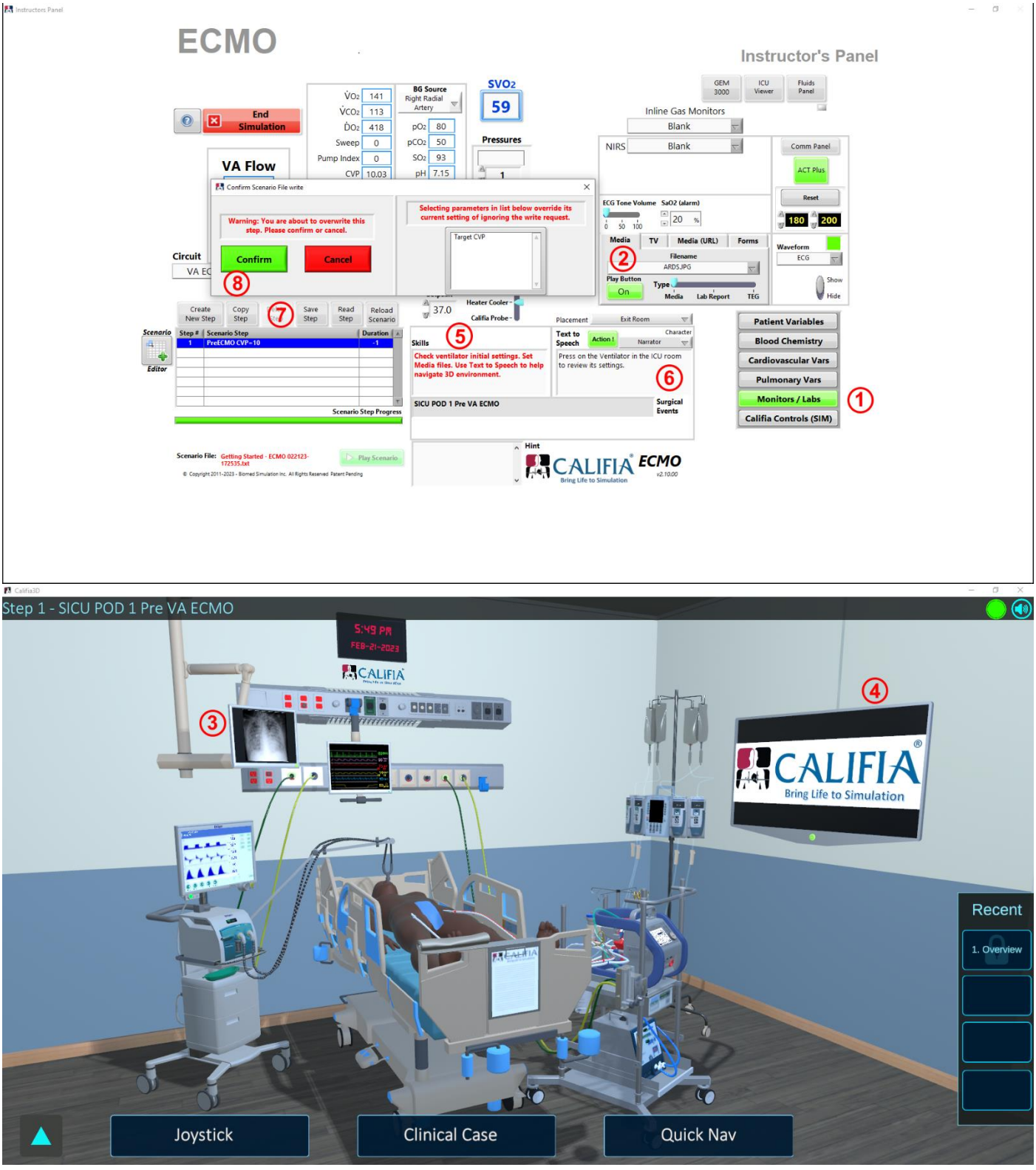

Figure 6.27 Step 1 edits

6.15.5 Scenario File Step 2: Nurse

Summon nurse to produce Arterial Blood Gases report, refer to Figure 6.28.

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Summon nurse*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following note in **Skills** field: *Room navigation.*

④ Add following note in **Surgical Events** field: *ABG.*

Surgical Events value displays along top of the Califia3D environment.

⑤ Add following in **Text to Speech** field: *Press button in lower left followed by phone button. Find Nurse 1 in pager and press Call button.*

⑥ Press arrow button in lower left of the Califia3D environment, followed by pressing the Phone button.

⑦ Use Up-Down buttons in pager to find Nurse1 then press the Call button to summon nurse.

⑧ Press **Run GEM3000 Report**.

⑨ Press **Save Step**** button. In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

Surgical Events

Hold <*Ctrl*> key to select multiple entries.

****** refers to the step having been modified and needs to be saved.

⑩ Press **Confirm** button to save step changes to scenario file.

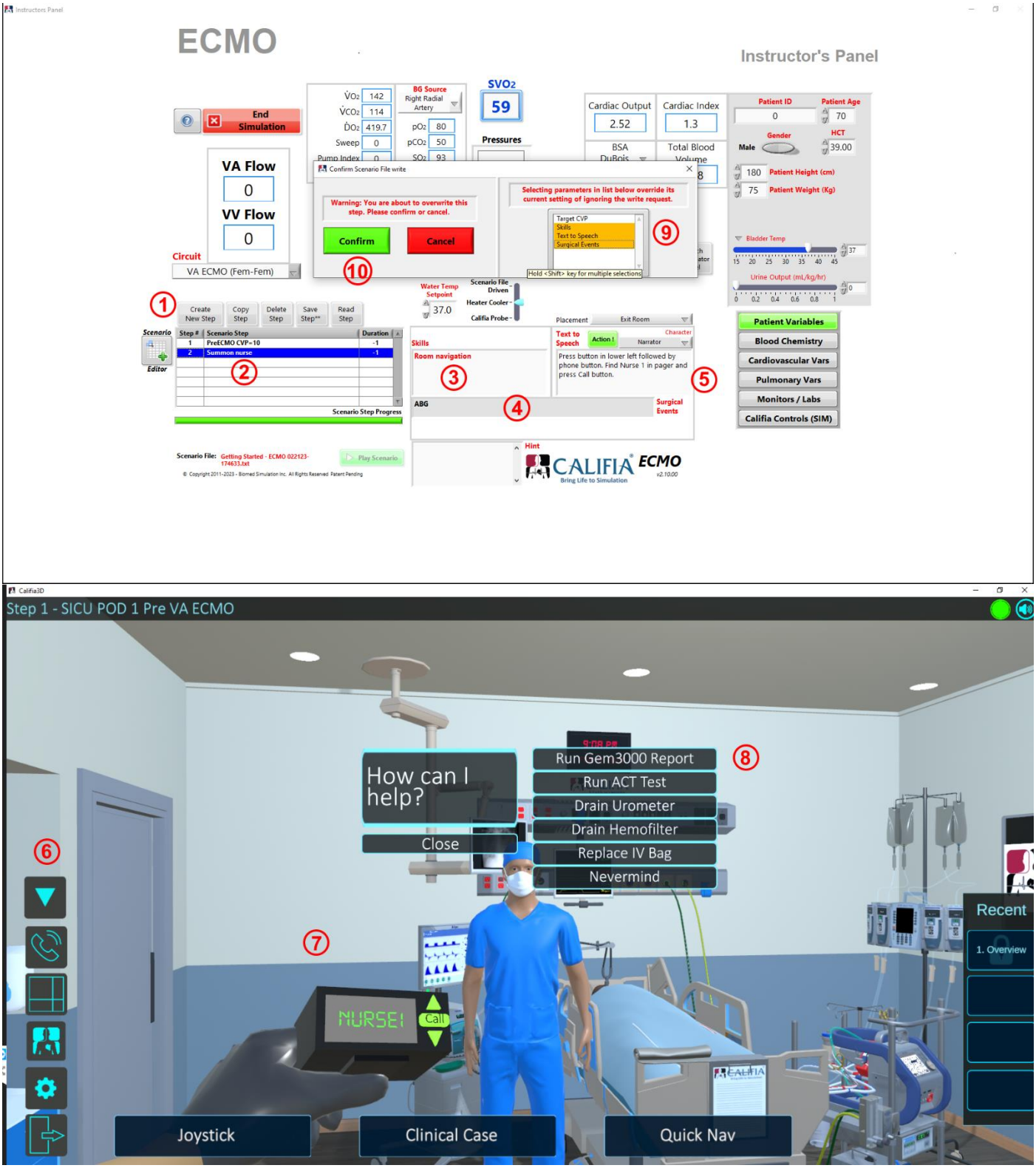

Figure 6.28 Step 2 - Nurse

6.15.6 Scenario File Step 3: Request ABG from nurse

Refer to Figure 6.29,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Request ABGs*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Text to Speech** field: *Request jem 3000 report. Find Left radial artery from syringe bubbles and select it.*

"*jem*" is a deliberate word misspell to ensure speech pronounciation is correct.

④ In the Califia3D environment, hover mouse over syringe bubbles above patient until **Left Radial Artery** is found then select it.

⑤ Press **Save Step**** button.

⑥ In the **Confirm Scenario File write** dialog select:

Text to Speech

⑦ Press **Confirm** button to save step changes to scenario file.

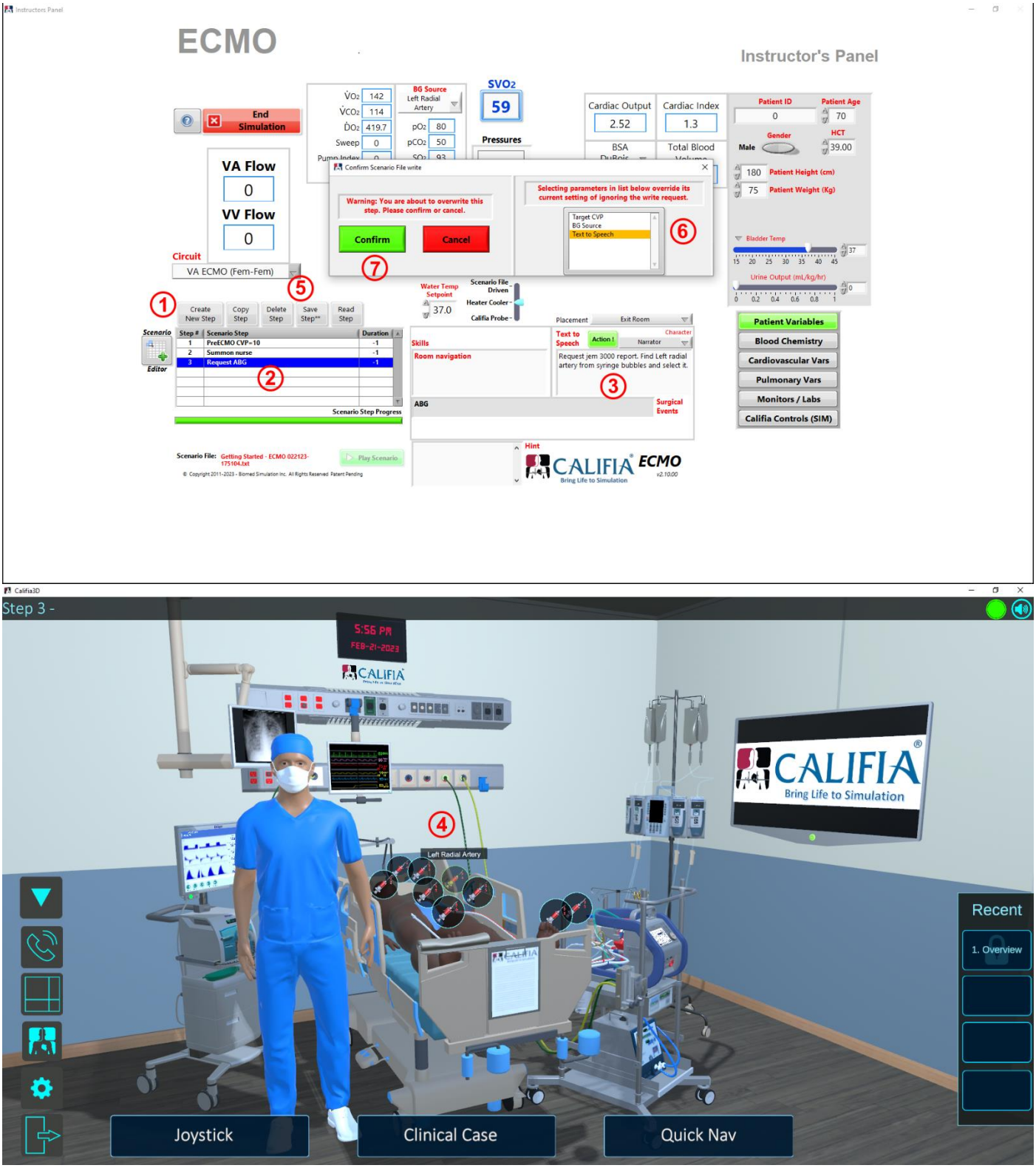

Figure 6.19 Step 3 – request ABG

6.15.7 Scenario File Step 4: ABG

Refer to Figure 6.30,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Review ABGs*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *Interpret ABG.*

Add following in **Text to Speech** field: *Press on clipboard at foot of the bed to bring up the latest arterial blood gases report. Click away from clipboard to put it away.*

④ In the Califia3D environment, press on the clipboard at foot of the bed to bring up the latest blood gases report. Click away from clipboard to put it away.

⑤ Press **Save Step**** button.

⑥ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

⑦ Press **Confirm** button to save step changes to scenario file.

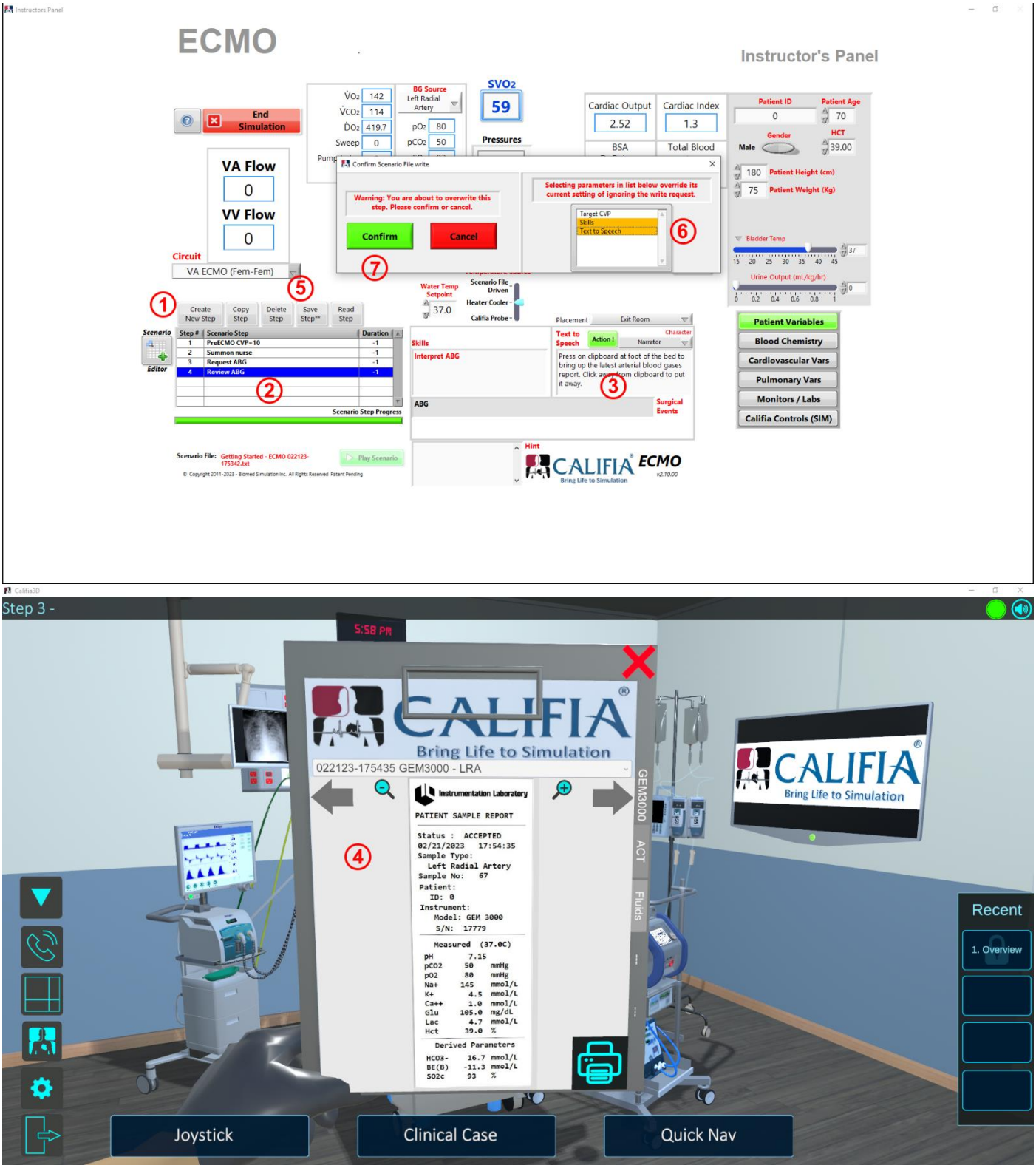

Figure 6.30 Step 4 –ABG report

6.15.8 Scenario File Step 5: Select cannulas

Refer to Figure 6.31,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Select cannulas*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *Review cannula selection.*

Add following in **Text to Speech** field: *Press on either cannula handle to approach it. Press it again and select Change Cannula. Review selection list then close it. You can repeat the process on the second cannula.*

④ In the Califia3D environment, from the Overview position, press on either femoral cannula to navigate towards it. Press the cannula once more to bring up the **Change Cannula** menu. Select **Change Cannula** to review the cannula listing. Click away from it or press the X button to put it away.

⑤ Press **Save Step**** button.

⑥ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

⑦ Press **Confirm** button to save step changes to scenario file.

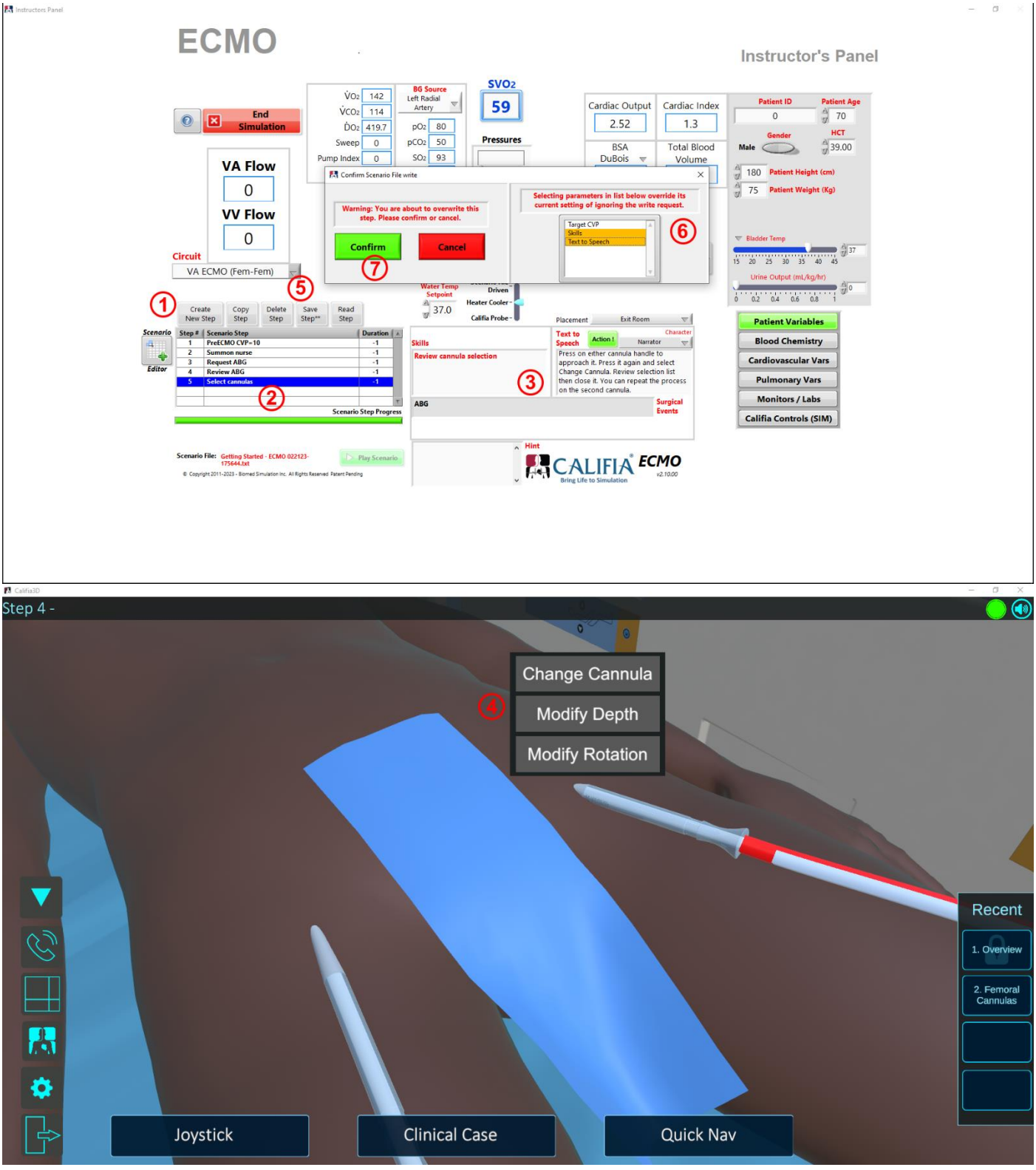

Figure 6.31 Step 5 - Cannulas

6.15.9 Scenario File Step 6: Gas Blender

Refer to Figure 6.32,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Set gas blender*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *Sweep=2, FiO2=100.*

Add following in **Text to Speech** field: *Press the Overview button under Recent. Then press the Gas Blender on the eckmo cart. Turn knobs to set new values.*

"*eckmo*" is a deliberate word misspell to ensure speech pronounciation is correct.

Add following in **Surgical Event** field: *ECMO*

④ In the Califia3D environment, from the Overview position, find the gas blender on the ECMO cart, press it to navigate to it. Change sweep and FiO2 values by turning respective knobs.

⑤ Press **Save Step**** button.

⑥ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

Surgical Events

⑦ Press **Confirm** button to save step changes to scenario file.

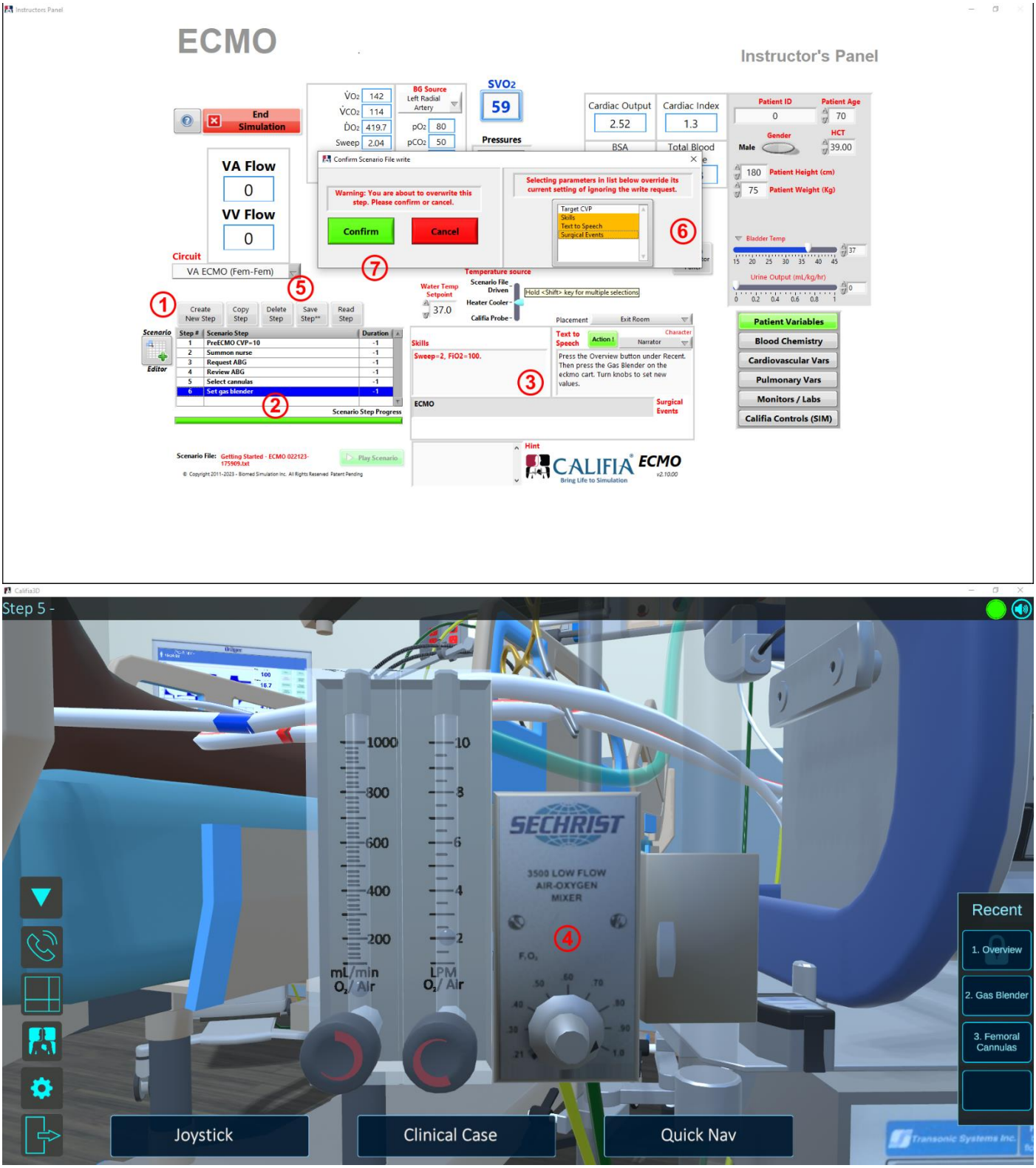

Figure 6.32 Step 6 – Gas Blender

6.15.10 Scenario File Step 7: Set pump

Refer to Figure 6.33,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Set pump*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *RPM = 2000.*

Add following in **Text to Speech** field: *Press on the pump next to the gas blender to approach its front panel. Turn knob until RPM is about 2000.*

④ In the Califia3D environment, from the Gas Blender position, press on the ECMO pump next to it to move the camera to the pump's front panel. Turn knob to set RPM to about 2000.

⑤ Press **Save Step**** button.

⑥ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

⑦ Press **Confirm** button to save step changes to scenario file.

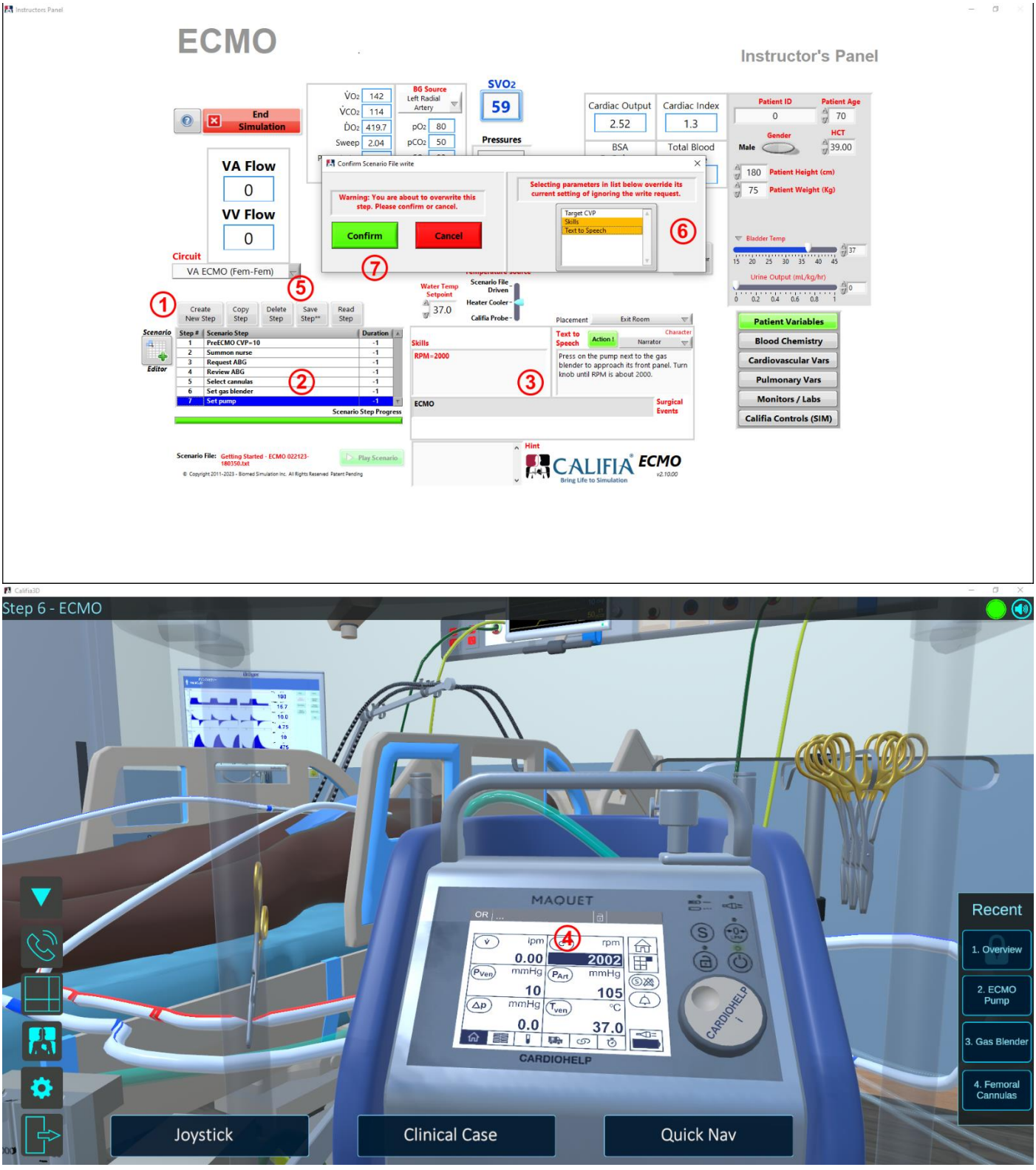

Figure 6.33 Step 7 – Set pump

6.15.11 Scenario File Step 8: Go on ECMO

Refer to Figure 6.34,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Go on ECMO*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *remove clamp.*

Add following in **Text to Speech** field: *Find the vitals monitor in the back wall and press it. It should anchor on the top right corner of the window. Remove the tubing clamp to allow for flow. Flow will fluctuate for a few seconds then settle.*

④ In the Califia3D environment, from the ECMO pump position, find the Vitals Monitor along the back wall and press it to anchor it on the top right corner of the Califia3D environment.

⑤ Next, find the tubing clamp on the delivery or return line, press the clamp to remove and generate forward flow. The first few seconds, you'll notice flow rate fluctuates but it settles quickly.

⑥ Press **Save Step**** button.

⑦ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

⑧ Press **Confirm** button to save step changes to scenario file.

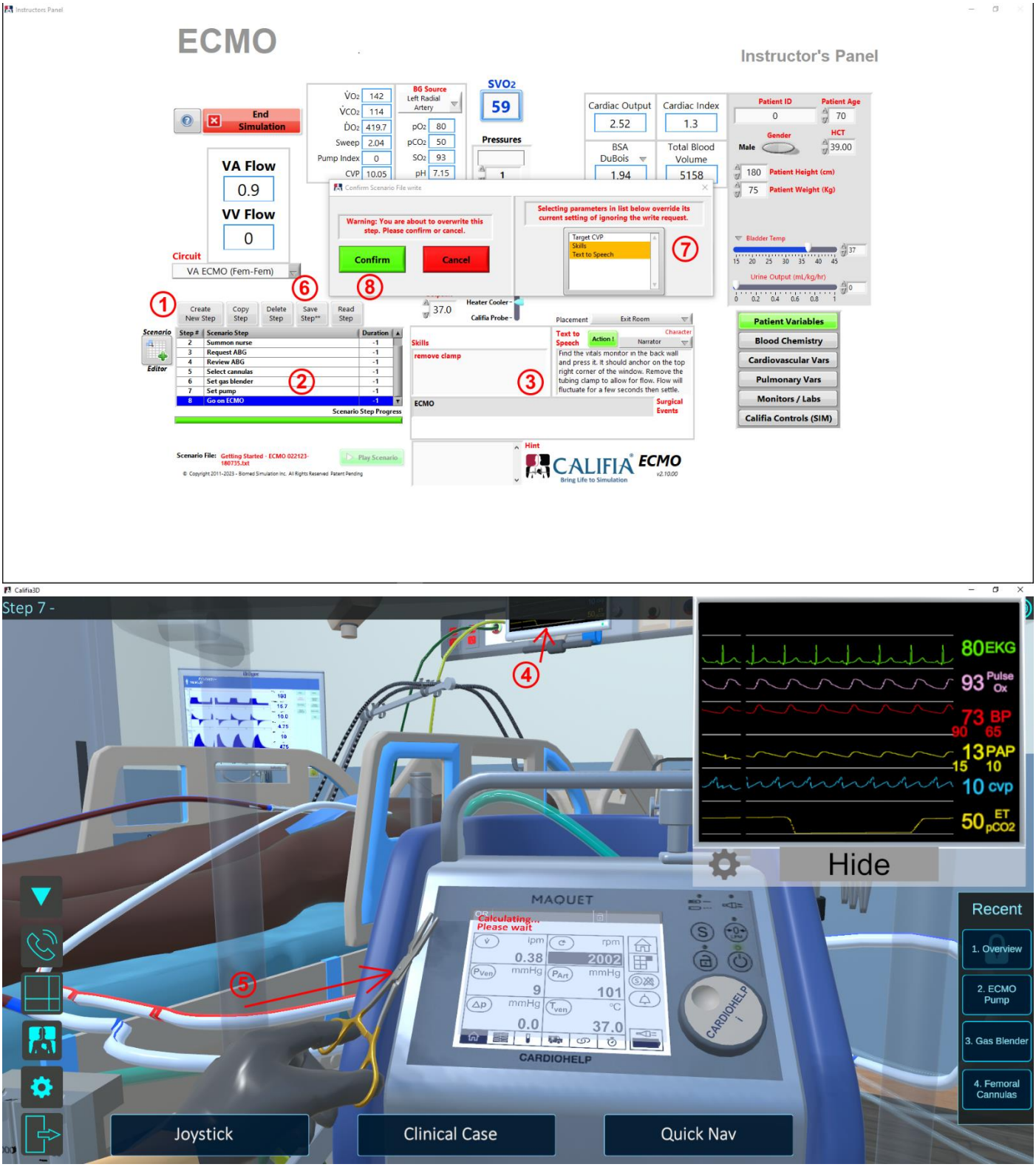

Figure 6.34 Step 8 – Go on ECMO

6.15.12 Scenario File Step 9: Increase RPM

Refer to Figure 6.35,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Increase RPM*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *RPM = 3000.*

Add following in **Text to Speech** field: *take note of changes in scene such as blood colors in tubing and pressure readings in the pump's panel and vitals monitor. Patient should be on partial eckmo. Finally set RPM to 3000.*

④ Set **Oxygenator Pressure Drop** to *10 mmHg/LPM.*

⑤ In the Califia3D environment, turn pump knob to set RPM to about *3000.*

Observe **ΔP** is now *41.8*; exactly 10 times flow rate as expected.

⑥ Press **Save Step**** button.

⑦ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

Oxygenator Pressure Drop

⑧ Press **Confirm** button to save step changes to scenario file.

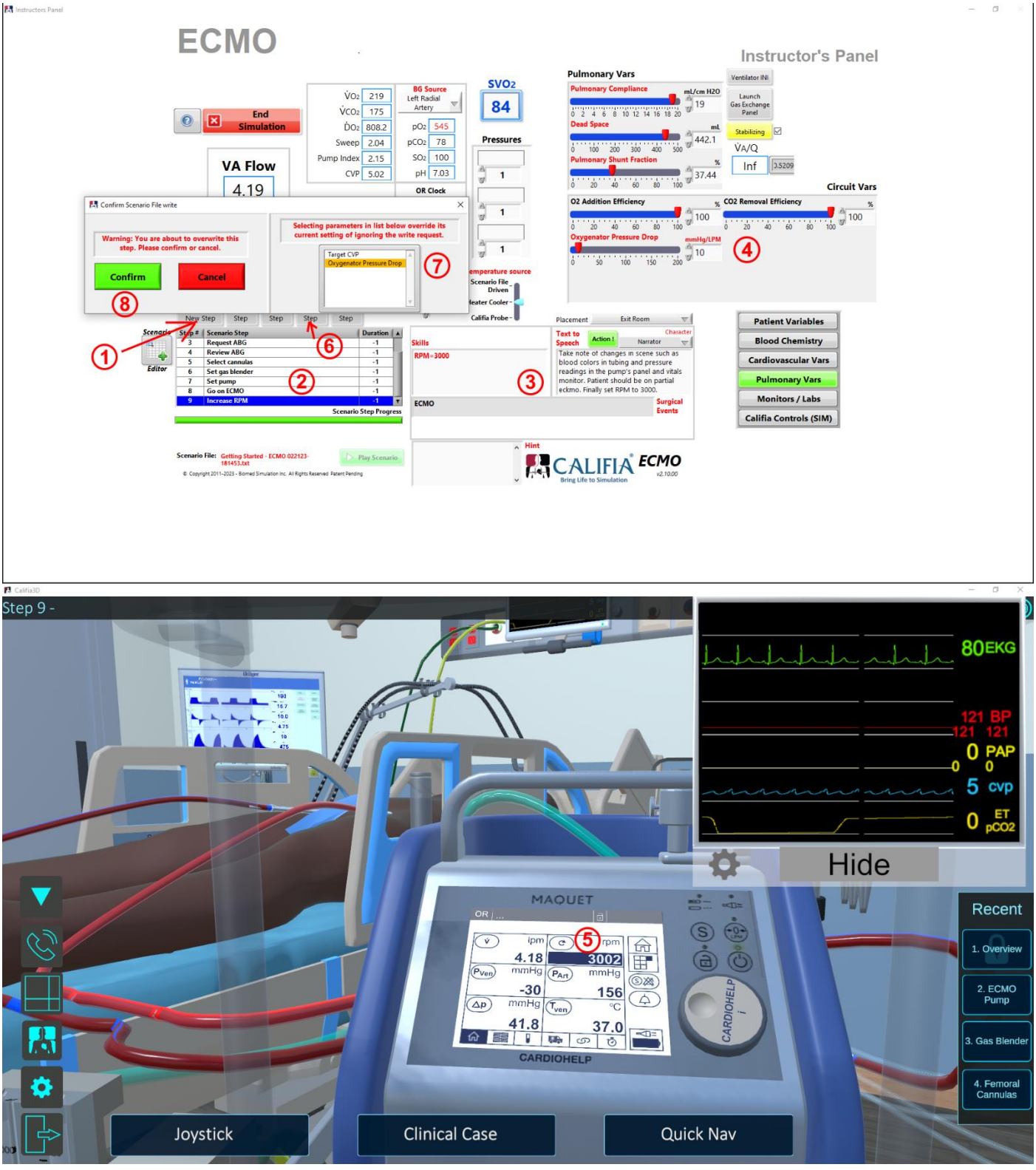

Figure 6.35 Step 9 – Increase RPM

6.15.13 Scenario File Step 10: Increase Gas Sweep

Refer to Figure 6.36,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Increase gas sweep*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *Sweep = 4.*

Add following in **Text to Speech** field: *Approach gas blender and set sweep to about 4 liters per minute. This should lower pCO2.*

④ In the Califia3D environment, press on the gas blender to approach it. Turn sweep knob to about 4 LPM.

⑤ Observe pCO2 decreases to reasonable range, in the low 50s.

The nurse could be summoned to draw blood gases and produce another report.

⑥ Press **Save Step**** button.

⑦ In the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

⑧ Press **Confirm** button to save step changes to scenario file.

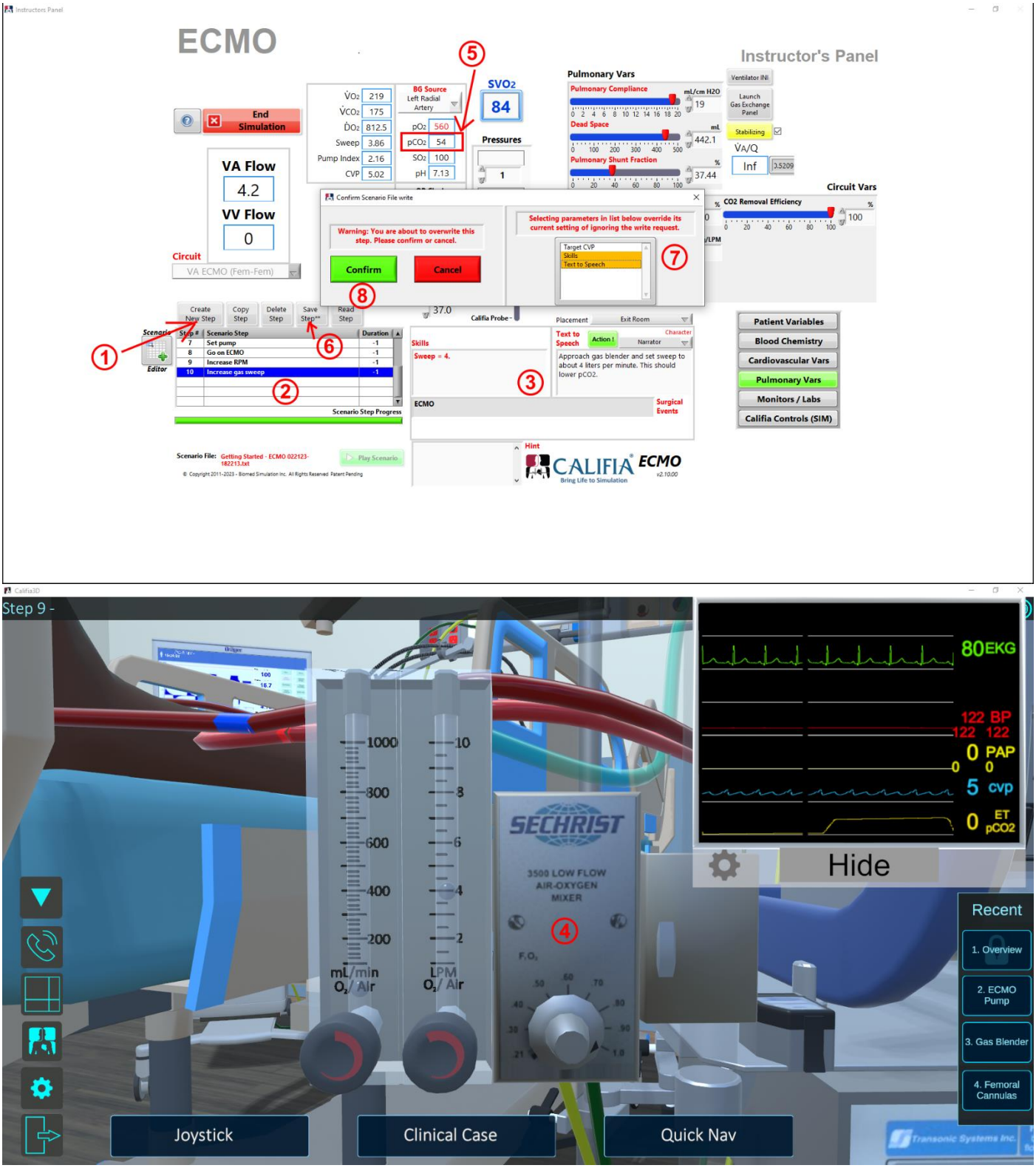

Figure 6.36 Step 10 – Increase gas sweep

6.15.14 Scenario File Step 11: Event: High Oxygenator Pressure Drop

Refer to Figure 6.37,

① Press **Create New Step.**

② Step #2 is added to scenario table; type ***Event: high oxygenator pressure drop*** for **Scenario Step** then press <*Enter*> on keyboard or click away with the mouse.

③ Add following in **Skills** field: *Vent FiO2=30%. Detect large pressure drop across oxygenator. Review options. Oxygenator change out?*

Add following in **Text to Speech** field: *Since patient is on full eckmo, approach ventilator and set F I O2 to about 30%. Return to pump to monitor all parameters.*

④ Set **Oxygenator Pressure Drop** to *70 mmHg/LPM.*

⑤ Set **Dead Space** to about *472 mL*

This change only affects blood gases once patient's heart is able to eject blood.

⑥ In the Califia3D environment, press on the ventilator to approach it. Select **FiO2** button and turn knob to set FiO2 to about *30%*. Press knob to accept new value. Return to pump panel and monitor all parameters.

Key observations:

Arterial pressure in Vitals monitor has a small range – 75/72.

ECMO flow rate is much lower.

Though not shown in Figure, pressure drop across oxygenator, ΔP, is very large.

⑦ Press **Save Step**** button and in the **Confirm Scenario File write** dialog select:

Skills

Text to Speech

⑧ Press **Confirm** button to save step changes to scenario file.

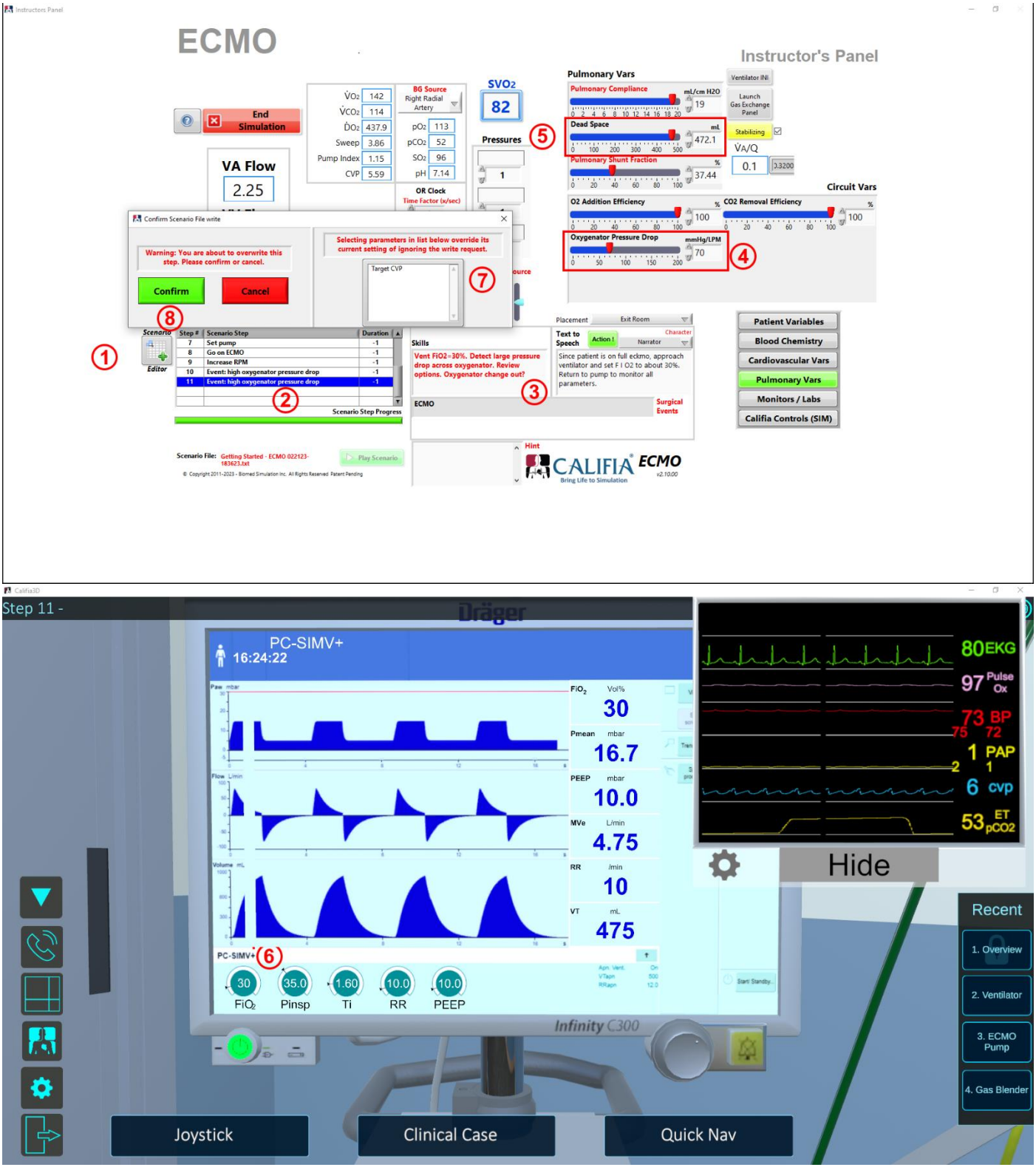

Figure 6.37 Step 11 – Event setup

Working on icons for document in process.

Icon	Description	Icon	Image
	Help / Note		
	Warning		
	Warning / Alert		
	Time / Duration