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Emergent Cardiopulmonary Bypass during Cardiac Surgery

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Abstract: During orientation to the cardiac surgery operating room, new staff may not be exposed to emergent situations. Allowing team members the opportunity to practice their roles during less common, high-stakes emergency cardiac surgical scenarios may better prepare them when crises do arise in the OR. The Emergency Cardiopulmonary Bypass Course was developed to meet the needs of new staff starting in cardiac surgery. Recently, the course has expanded to include experienced staff. This communication describes a high fidelity simulation based course that includes four emergent cardiac surgery scenarios. **Keywords:** cardiopulmonary bypass, cardiac surgery, high-fidelity perfusion simulation, emergency bypass. *JECT. 2015;47:245–250*

DEMOGRAPHICS

We describe four emergency initiations of cardiopulmonary bypass (CPB) scenarios during cardiac surgery. The scenarios are designed for an eight-member multidisciplinary cardiac surgical team.

Module Title: Emergency Cardiopulmonary Bypass Initiation during Cardiac Surgery
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Appropriate for the Following Learning Groups

Cardiac surgeons and residents

Cardiac anesthesiologists, residents, and certified registered nurse anesthetists (CRNA)

Certified surgical technologists (CST) and certified surgical assistants (CSA) and students

Cardiac surgical physician assistants and students

Certified cardiovascular perfusionists and perfusion students

Operating room (OR) registered nurses (RN)

Specialties: Cardiac surgery, cardiac anesthesia, perfusion, certified registered nurse anesthetists, OR nurses, surgical assistants, and surgical technologists.

CURRICULAR INFORMATION

Educational Rationale

During orientation to the cardiac surgery operating room (OR), new staff may not be exposed to emergent situations. Allowing team members the opportunity to practice their roles during less common, high-stake emergency cardiac surgical scenarios may better prepare them when crises do arise in the OR. The Emergency CPB course was developed to meet the needs of new staff starting in cardiac surgery. Recently, the course has expanded to include experienced staff. This communication describes a high-fidelity simulation–based course that includes four emergent cardiac surgery scenarios.

Learning Objectives

The learning objectives for the four scenarios are similar. After participation in the scenarios, learners will have increased confidence and comfort in their role during emergent CPB situations.

Medical Knowledge

The learners must recognize and respond to the surgeon's unscheduled decision to change cannulation sites during surgical preparation and conduct CPB.

Patient Care

Patients being prepared for cardiac surgery occasionally require emergent initiation of CPB for hypotensive reaction

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to the induction of anesthesia, failure of ascending aortic cannulation (dissection), and post-CPB protamine reactions. These scenarios often require rapid initiation of mechanical cardiopulmonary support with cannulae and equipment not frequently used. In the routine course of cardiac surgical patient care, the cardiac surgical team does not get to practice these emergencies with enough frequency to remain proficient or confident.

Interpersonal and Communication Skills

All team members must demonstrate their situational awareness to follow the surgeon's verbal orders and respond appropriately to perform their role in the emergency cannulation scenarios. Crew Resource Management teamwork and communication principles such as speaking up and sharing concerns to improve patient and team safety will be practiced by all team members (1).

The need for cardiac emergency drills is encouraged to build skills and confidence to respond to emergencies in the OR environment. Simulation is an effective method to use to train OR staff (2).

For high fidelity, we use the Orpheus cardiopulmonary bypass patient simulator in these drills (3).

Professionalism

Principles of communication, callback, mutual respect, situational awareness, and calling for clarification are practiced during the simulations.

Pre-Course Reading Materials

Pre-reading material is not required. Publications regarding emergency cannulation situations for resident training during CPB are available (4). Reviewing the femoral arterial cannula manufacturer instructions for use and device warnings are useful preparation for these scenarios and everyday practice in the OR.

Assessment Instruments

No assessment instrument has been developed for the expected behaviors in these scenarios. In the future, we will use the B-Line Medical Sim Capture video system with pre-defined behaviors (annotations) listed to identify the exact time during the simulation where the behaviors are exhibited by the learners. The annotations on the video can serve as check points to evaluate the fundamental list of CSA/CST/RN and other team member skills and communication keys. Typical post-simulation session instruments are used to evaluate the learners' responses to the training.

Preparation

Video Capture System:

- Video and audio recording capability with playback. (SimCapture®, B-Line Medical, Washington, DC. http://www.blinemedical.com/simcaptureoverview.aspx)

Monitors Required

- Anesthesia machine with conventional monitors for ventilator, expired pCO_2, pulse oximeter, and other continuously monitored parameters.
- Patient hemodynamic conventional monitor for arterial and venous blood pressures, electrocardiograph (ECG), and other parameters.

Equipment Needed

- Operating room table
- Anesthesia machine
- Patient mannequin with lungs and heart (The Chamberlain Group, Perfusion Beating Heart Trainer®, Great Barrington, MA, www.thecgroup.com)
- Heart–lung machine (Sorin S5®, Sorin USA, CO, www.sorin.com)
- Cardiopulmonary bypass conventional oxygenator and tubing circuit
- Patient mannequin groin with femoral artery access
- Cardiopulmonary bypass patient simulator (Orpheus® Perfusion Simulator, Terumo Cardiovascular Group, Ann Arbor, MI, www.terumo-cvs.com\orpheus
- Mayo stand, back table, additional tables for setup as needed
- Cardiac surgery instruments and supplies
- Cardiac surgical supplies in adjacent storage room for retrieval as needed

Other Equipment Required

- Ascending aortic DLP® Straight Tip Arterial Cannula (Medtronic DLP, Minneapolis, MN, www.medtronic.com)
- Dual-Stage Venous Return Cannula (Terumo Cardiovascular Group, www.terumo-cvs.com)
- DLP® Femoral Arterial Cannula (Medtronic Corporation, www.medtronic.com)

Staff Required

The scenarios involve RN, CST, CSA, perfusionists, anesthesia providers, and surgeons. All four scenarios were written to include a team member from each discipline.

Participants/Learners

The surgeon and anesthesia providers are the actors, and facilitate the scenario for the balance of the team who are the learners.

Simulation Scripts for All Roles

Scripts for the cardiac surgeon, the CRNA/anesthesiologist and the perfusionist are outlined for each of the four scenarios. The other staff roles are responding to the scripts from the participating simulation facilitators.

Supporting Materials

The manufacturer's instructions for use for the cannulae kits are very helpful.

Time Duration

Each of the four modules is scheduled for 10- to15-minute duration. The debrief period after each simulation is scheduled for 15–20 minutes.

SIMULATION EXERCISES

Case Stem

Adult patient, supine on OR table with cardiac surgical team surrounding the patient.

Simulation Flow Tables

Scenario 1: Emergency initiation of CPB via the femoral vessels; calcified aorta is discovered after sternotomy.

Learner Introduction

The surgeon comes in to the OR to do a briefing in the morning with the patient in the room prior to induction.

Actor Briefing

During a pre-incision anesthesia emergency, it may become necessary to cannulate the femoral artery and femoral vein to imitate emergency CPB.

Objectives

1. Demonstrate team communication to accomplish femoral cannulation.
2. List the steps to cannulate a CPB patient via the femoral vein and artery.
3. Select cannulae, insert cannulae, and connect cannulae safely to CPB circuit lines.
4. Describe your role in the femoral cannulation process.

See Table 1

Scenario 1 Debriefing

1. Were there issues with communication, terminology, or physician verbal orders?
2. Was any special equipment needed—external/internal paddles, push code light?
3. What is the step-by-step role of the RN/CST/CSA?
4. How was the interaction with other team members?
5. Were there any special cannulae requirements?
6. What are the percutaneous insertion kit components and insertion techniques?
7. Insert cannulae and connect to heart–lung machine.
8. Were there any safety issues?

Table 1. Scenario 1: Simulation flow for calcified aorta to femoral arterial cannulation conversion.

State	Patient–Surgeon	Learner Action	Operator
1. Anesthesia induction complete; surgical team assembled in OR suite	Patient supine on OR table prepared and draped; patient exhibits normal hemodynamic response to anesthesia	Recall briefing; ready to follow physician verbal orders; attentive during surgical time-out; learners are monitoring patient hemodynamics	Set Orpheus baseline conditions to include normal blood pressure and ECG; assure hemodynamic monitor is displaying normal values
2. Surgical procedure pause: surgeon calls for time-out	Patient-monitored parameters within normal limits; surgeon states patient identifier and procedure information	Listen, acknowledge, and question as appropriate during time-out; contribute to time-out as needed; circulating RN documents time-out	Orpheus blood pressure and ECG parameters are altered to mimic normal patient background variation
3. Prepare the surgical field; sternotomy is made	Patient thorax is opened and heart is exposed; surgeon palpates the aorta	CSA and CST assist the surgeon; listen for instrument requests; surgical team is ready for any event	Orpheus blood pressure and ECG parameters are altered to mimic normal patient background variation
4. Calcified aorta is discovered; surgeon gives verbal order for femoral cannulation	Surgeon reports discovery of significant calcification of aorta; discussion may ensue to present surgical options	Learners hear and acknowledge surgeon verbal order; learners take action to gather necessary supplies for femoral cannulation	Orpheus blood pressure and ECG parameters are altered to mimic normal patient background variation
5. Expose femoral vessels; anticoagulate patient; confirm safe anticoagulation dosing and effect	Surgeon makes groin incision; surgeon asks for femoral cannulation kit device components to perform steps in femoral cannulation	CST and CSA working with circulating RN provide surgeon with femoral cannula device components with accuracy and in the order required	Orpheus blood pressure and ECG parameters are altered to mimic normal patient background variation
6. Insert and connect cannula to proper bypass circuit lines; initiate CPB safely; control wound, tubing, and bleeding	Surgeon positions femoral arterial cannula with the aid of CST; surgeon connects correct perfusion blood line to arterial cannula	Learner confirms safe complete femoral cannulation; learner attention moves back to the thorax; prepare for venous cannulation in atrium	Orpheus operator makes the adjustments to the simulator to reflect arterial cannulation, test transfusion, and the normal physiologic response to CPB initiation
Ending point: patient is safely on CPB	Patient blood flow and pressure are stable; normal hemodynamic response to CPB is present	Learner prepares to assist surgeon in placement of cardioplegia delivery cannula and line	Orpheus blood pressure and ECG parameters are altered to mimic normal patient background variation while on CPB

Scenario 2: Emergency re-initiation of CPB via the great arteries after successful de-cannulation and protamine administration.

Learner Introduction

At the end of CPB and after administration of protamine, the patient has been de-cannulated. The surgeon and CSA are controlling bleeding. A CST comes in to give a break and a hand off is expected.

Actor Briefing

The patient goes into cardiac or cardiorespiratory failure. The physician decides that the patient must be placed back on CPB.

Objectives

1. Demonstrate team communication to accomplish re-cannulation.
2. List the steps to re-cannulate a CPB patient during failure after cardiac surgery.
3. Organize re-insertion of cannulae and reconnection safely to CPB circuit lines.
4. Describe your role in the emergency re-cannulation process.
5. Practice de-airing blood lines.

See Table 2

Scenario 2 Debriefing

1. How should the patient be monitored after protamine sulfate administration?
2. How do we assure anticoagulation?
3. What is done to assure proper line connection?
4. What is the procedure to assure safe de-airing of lines?
5. How was the communication during the emergency re-cannulation for CPB?

Scenario 3: Conversion from ascending aortic cannulation to femoral artery cannulation during an unexpected ascending aortic dissection during CPB.

Learner Introduction

From time to time during CPB, events occur during the first minutes of the pump run where the surgeon may change their routine. The RN, CST, and CSA should be ready for the unexpected and flexible to help the surgeon care for the patient.

Actor Briefing

During the very beginning of CPB, communication between the perfusionist, surgeon, and anesthesia provider lead to the diagnosis of an ascending aortic aneurysm. The team decides to move the ascending aortic cannula to the femoral artery.

Objectives

1. Demonstrate team communication to accomplish femoral cannulation.
2. List the steps to cannulate a CPB patient via the femoral artery.
3. Select cannulae, insert cannulae, and connect cannulae safely to CPB circuit line.
4. Describe your role in the femoral alternate cannulation process.

See Table 3

Scenario 3 Debriefing

1. How was the diagnosis of ascending aortic dissection made?
2. What was done to assure proper line connection?
3. How did safe de-airing of lines occur?
4. How were the steps communicated for moving cannulation for CPB?
5. Were there any safety issues?

Scenario 4: Safe removal of air from dropped femoral cannula during emergent re-initiation of CPB after termination of CPB.

Table 2. Scenario 2: Emergency re-initiation of CPB via the great arteries and right atrium.

State	Patient–Surgeon	Learner Action	Operator
1. Anesthesia induction	Patient supine on OR table prepared and draped	Recall briefing; ready to follow physician verbal orders	Set Orpheus conditions to include normal blood pressure and ECG
2. Post-CPB, protamine is administered	ACT is back to normal; surgeon de-cannulates patient	Monitor patient hemodynamics; assist the surgeon	Start Orpheus trend to simulate protamine reaction
3. Patient is hypotensive, fibrillates	Anesthesiologist and surgeon report patient critical; cardiac compressions begin	Recognize lack of systolic blood pressure and fibrillation	Confirm ventricular fibrillation on the Orpheus
4. Surgeon calls for re-initiation of CPB	Re-cannulate the right atrium and ascending aorta; de-air and connect lines correctly	Call for help; communicate MD decision to help; retrieve blood lines	Use Orpheus output to simulate asystole and absence of blood pressure; follow surgeon
Ending point: patient is safely on CPB and blood pressure stable	Patient blood flow and pressure are stable; normal hemodynamic response to CPB is present	Learner prepares to assist surgeon in placement of cardioplegia delivery cannula and line	Orpheus blood pressure and ECG parameters are altered to mimic normal CPB patient background variation

Table 3. Scenario 3: Conversion from ascending aortic cannulation to femoral artery cannulation during an unexpected ascending aortic dissection during CPB.

State	Patient–Surgeon	Learner Action	Operator
1. Anesthesia induction	Patient supine on OR table prepared and draped; on CPB	Ready to follow physician verbal orders; attentive during surgical time-out	Set Orpheus conditions to include normal blood pressure and ECG
2. Patient is going on CPB and aortic dissection is diagnosed	Perfusionist and surgeon make diagnosis of dissected aorta with anesthesiologist	Recognize the communication between perfusionist, anesthesia provider, and surgeon.	Use Orpheus to set high heart–lung machine arterial line pressure and low patient mean arterial blood pressure
3. Follow the verbal instructions of the surgeon to place the femoral cannula.	Control the bleeding in the ascending aorta	Gather the equipment and proper cannula to convert from the ascending aorta.	Keep patient blood pressure low, vascular resistance high with patient's heart beating
4. Reinitiate CPB with heart–lung machine	Heart–lung machine arterial line connected to the femoral artery cannula	Behavior: disconnect and reconnect the CPB arterial line to the correct cannula.	Set Orpheus to normal CPB hemodynamic settings for femoral arterial cannulation
Ending point: patient is safely on CPB and blood pressure stable.	Patient blood flow and pressure are stable; normal hemodynamic response to CPB is present	Learner prepares to assist surgeon in placement of cardioplegia delivery cannula and line	Orpheus blood pressure and ECG parameters are altered to mimic normal CPB patient background variation

Learner Introduction

The patient is off CPB and has received protamine to reverse the anticoagulant heparin. The surgeon is getting ready to move to the next patient procedure and the surgical team is drying up the patient and is considering closing the chest.

Actor Briefing

After being off CPB for a period and protamine reversal of heparin, the surgeon is called back to the OR to re-initiate CPB. Nothing is going correctly. While "crashing" back on CPB, the arterial cannula is dropped to the floor, the lines are contaminated and air enters the lines.

Objectives

1. Demonstrate team communication to accomplish recognition of contamination and air entrainment
2. Demonstrate what to do to reuse CPB tubing already handed off from the sterile field
3. List the steps to replace, separate, and de-air the arterial line
4. Practice manipulating air to the highest point in the arterial line under stress

See Table 4

Scenario 4 Debriefing

1. What was the process for gathering replacement sterile lines after contamination of pump lines or reusing lines already handed off field?
2. How was the air in the arterial line diagnosis made?
3. What are the steps in safe arterial line disconnection with clamping and line separation?
4. What was the process to assure safe de-airing of lines?
5. Were there any safety issues?
6. How can situational awareness impact this scenario?

Learner Feedback

At the completion of each course, learners complete an online evaluation form to evaluate their simulation learning experience.

Table 4. Scenario 4: Safe removal of air from dropped femoral cannula during emergent re-initiation of CPB after termination of CPB.

State	Patient–Surgeon	Learner Action	Operator
1. Anesthesia induction	Patient supine on OR table prepared and draped; just separated from CPB	Ready to follow physician verbal orders	Set Orpheus conditions to include normal post-CPB hemodynamics and ECG
2. Surgeon de-cannulates patient; follow the verbal instructions of the surgeon	After protamine infusion and de-cannulation; team recognizes patient needs to go back on CPB	Recognize the communication between perfusionist, anesthesia provider, and surgeon	Set Orpheus to reflect difficult patient after CPB separation; bradycardia and hypotension trend
3. Cannula is dropped and contaminated; air is entrained in perfusion circuit	Recognize air in the arterial and venous pump lines	Recognize the cannula being dropped and lines being contaminated.	Orpheus reflects patient low cardiac output and heart rate with hypotension
4. Air accidentally entrained in arterial and venous heart–lung machine lines	De-air and inspect the arterial line for air; de-air the venous blood line	Get replacement disposable items; disconnect, de-air, and reconnect the CPB arterial line to the cannula	Reflect patient hypotension and decreased heart rate
Ending point: arterial line is de-aired and it is safe to transfuse.	Patient blood flow and pressure are stable; normal hemodynamic response to CPB is present	Learner prepares to assist surgeon in placement of cardioplegia delivery cannula and line	Orpheus blood pressure and ECG mimic normal CPB patient background variation

Table 5. Post-simulation evaluation comments by learners.

Item	Open-Ended Comments
How did the simulation enhance your learning	Hands-on; Team work; Learned more about Perfusion and what they are doing back there; Learned why we do the things we do; It's a very good way to learn different situations; I was happy to learn more about reasons that we have to change our cannulation plans in the OR and how we should react to the changes; I think that this was completely worthwhile and would love to hear that more people are going to do these types of simulations; It was nice to think about the emergencies that could occur in the OR in a controlled environment. I now feel much more comfortable of what to do in an emergency situation should one occur. It helps take some of the anxiety of being a new person in the OR away.
Suggestions for future opportunities to enhance your learning	In the real OR, the lines coming to and from the table are marked with blue and red tape—in the simulation, I had gotten them mixed up because of no markings; There could be more distractions, more people, and a little more uncertainty

Comments are quotes collected during post-simulation evaluation by learners.

Open-ended summary evaluation items and learners' responses are listed in Table 5.

Comment

Caring for patients in the OR requires a multidisciplinary team with shared mental models (2). Simulation to train teams in high-reliability organizations and help assure patient and team safety is recommended. Simulation is an effective means to train teams on high-risk emergencies, and can include multiple participant roles in the OR (5).

Simulation training can enhance communication and teamwork (6–8), as well as increase awareness during surgery (6). Simulation can also provide opportunities to improve protocols for safe patient care (7). Team simulations should be informed by failure mode and effect analyses and national multidisciplinary evidence-based standards and guidelines for perfusion practice (downloaded December 6, 2015, from http://www.amsect.org/perfusion-safety/). During the simulations, team members discovered opportunities to improve protocols and build team rapport, which can carry over into the OR and everyday practice.

Evaluation is two-dimensional. Learners may evaluate the simulation experience, and facilitators may evaluate the learner competency. We have not used these simulations to evaluate learner competency, but we have the tools. The B-Line SimCapture® video system holds promise to both list, annotate and capture evidence of learner demonstration of minimal competencies during their orientation to the OR.

During these simulations, OR team members have the opportunity to demonstrate non-technical skills such as team working, task management, situation awareness, and decision-making (9). Team performance is also improved following emergency simulation training (5). When cardiac surgical teams include cardiothoracic surgical residents, the residents benefit from emergency and crisis training in a boot camp–type setting (4).

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