Introduction to Immersive Simulation

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Medical simulation enables participants to experience and engage in life-like scenarios where real world elements are reproduced in a structured and controlled environment. The use of medical simulation within human medical school curricula has become mainstream and studies have demonstrated that medical students trained using a curriculum where simulation was featured have clinical performances equal to or better than a traditional clinical training curriculum. Anesthesia became the first of the medical specialties to develop the concept of medical simulation training when SimOne was developed at USC in the late 1960's.[1] Borrowing from lessons learned in the aviation industry, medical anesthesia residents could experience a breadth and depth of patient scenarios, from simple to complex, all without putting actual patients at risk. Although today's high fidelity medical simulation products are extremely sophisticated compared with early simulations such as SimOne, the ability to learn during a simulation scenario is not necessarily related to the sophistication of the simulation.[2] Simply stated it is not the amount of technology that facilitates learning rather it is how a particular technology addresses the ways in which adults learn. An anesthesia simulation environment incorporates the simulation technology with a life like atmosphere creating a virtual surgery suite that the student becomes immersed in. Of the many features of medical simulations that promote effective learning, the ability of a simulation environment to provide feedback[3] and to permit the learners to engage in repetitive practice have been shown to be vital.[2] The most effective simulation environments allow students to practice repetitively and provide both immediate and post experience feedback as to their performance. Immediate feedback occurs during the scenario (injection of atropine results in an increase in heart rate) while post experience feedback generally occurs within 30 minutes after the scenario has completed. The post experience feedback is called debriefing and combines student reflection with peer and instructor input.[4]

Although high fidelity medical simulation has been available in human medical and nursing programs for many years, the high cost of such systems are not aligned with the fiscal realities of veterinary education. The Stage III™ simulation environment that you are about to experience was designed be both portable and to incorporate features of medical simulations that lead to effective learning. Originally offered as an elective course, critical care and anesthesia, simulations using Stage III have been integrated into the core veterinary curriculum at the University of Arizona and at WSU. Student acceptance has been enthusiastic and the live animal anesthesia skills of students completing the course show demonstrable improvement.[5] We are hopeful that you will have a similar experience.

How Does the Simulation Work?

The Stage III simulation environment (Figure 1) consists of a mocked-up surgical suite with anesthesia machine and vital signs monitor, a canine manikin and a large monitor screen which displays patient vital signs and waveforms that are generated from an operator managed computer simulation. As participants connect anesthesia and monitoring equipment the display screen populates with flow rates, waveforms and patient vital signs. A checklist of items to be connected to the patient manikin is presented in Table 1.

Figure 1. The Stage III Simulation Environment

Table 1. Connection Checklist

Oxygen Flow Rate	☐
Vaporizer Setting	☐
Esophageal Stethoscope	☐
IV Fluid Line	☐
Sidestream Capnograph Sensor	☐
ECG Leads	☐
NIBP Cuff	☐
Esophageal Temperature Probe	☐
Pulse Oximeter Probe	☐

Simulation Interaction

There are two principles that we ask all simulation participants to strictly adhere to:

1. **Suspend Your Disbelief.** The learning potential of a simulation exercise is influenced by the amount of "buy in" from each participant. Participants who focus on the manikin and vital signs monitor as if it is an actual patient, treating it as such, will benefit greatly from the simulation experience. This is easier for some than it for others but realizing that suspension of disbelief greatly affects your potential for learning is quite helpful.
2. **What Happens in Simulation Stays in Simulation**. Key to the effectiveness of all medical simulations is the establishment of a safe space for the participants to learn, a space free of negative repercussions. This is vital as it permits participants to freely experiment with different anesthetic techniques without worrying about stigma from their choices. As such all participants agree not to discuss particular aspects of the simulation outside of the session.

Anesthesia simulation sessions generally involve a small number (2-4) of simulation participants who function as anesthesia providers or as other clinicians (surgeons, endoscopists). In addition to the simulation participants, sessions often include members of the simulation team known as confederates who may serve one or more roles in the scenario. Confederates perform vital functions acting as clinicians, students, owners or technicians and can greatly enhance the realism and flow of a scenario making sure that the targeted objectives are addressed.

As the simulation session unfolds, the simulated patient's vital signs may change in response to actions taken by the anesthetist, the surgical procedure or by the programming within the scenario. The anesthetist responds to these changes just as they would respond to an anesthetized patient by adjusting the anesthesia vaporizer setting, oxygen flow rate, ventilation, type of fluids/ rate administered, or by the administration of IV drugs. In turn, the simulated patient responds to these interventions by displaying changes in heart rate, rhythm and other monitored vital signs.

A powerful feature of simulation as a learning tool is the ability to suspend time. Participants struggling with a particular portion of a scenario can ask for a time out wherein the simulation freezes at that point and the simulated patient's condition does not change. The time out feature allows participants to discuss the scenario without the pressures of time and a potentially decompensating patient. Once discussion is complete, the simulation resumes.

Anesthesia Scenarios

Different anesthesia scenario sketches are designed to reinforce specific topics. The scenario sketch is first created using a limited set (usually 3-5) of learning objectives that are important for the student to demonstrate completion of during the scenario. The sketch includes a patient synopsis that gives details about the patient, a flow chart progression of events that details different simulation states and patient parameters, staging instructions describing the equipment required for the scenario, and a list of debriefing questions that target each of the learning objectives. The sketch is a self-explanatory document of how the scenario runs and is designed to be used by any instructor who wishes to present a simulation scenario. Scenario sketches are used by the simulation team as the blueprint for a particular scenario and are not shared with participants.

After the sketch is created it is used to generate a student prep sheet that elaborates on the patient synopsis, describing patient signalment, including preoperative laboratory or imaging data and describing either the anesthetic protocol or providing a table of anesthetics from which the student may choose for the patient. The student is told at what point the simulation begins (induction, mid-surgery), the approximate duration of the simulation (most are 10-20 min) and finally what the learning objectives are. Learning objectives for beginning scenarios may be quite specific (correctly connect ECG leads) while later more advanced scenarios may have more general objectives (respond appropriately to changes in heart rate, rhythm, and blood pressure).

Each simulation scenario is fairly brief being only about 15 min in duration. Lab participants typically rotate through the scenarios in groups of 4 and those lab attendees not actively participating in a specific scenario have an important role as observer. Upon scenario completion, we take a short break and reconvene to break down or debrief the simulation experience. The observers are critical to the debriefing process as they view the scenario from a third person perspective and will pick up on nuances that the active participants are likely to miss owing to their engagement in the scenario. The debriefing process is typically twice as long as is the actual scenario and is where much of the learning occurs.

Advanced Anesthesia Simulation

General Objectives for All Simulation Scenarios:

1. Demonstrate ability to correctly place physiologic monitoring equipment on an anesthetized patient.
2. Mark and maintain an anesthetic record for an anesthetized canine patient
3. Identify signs of complications in an anesthetized dog.
4. Institute appropriate management (depth of anesthesia, fluids) to address and manage complications.
5. Respond to changes to heart rate and rhythm, blood pressure or any other physiologic parameter in a timely and appropriate fashion.
6. Initiate direct communication with surgery room team members
7. Demonstrate ability to calculate and deliver fluid administration rates

Critical Actions:

1. Properly Connect ECG Leads using ECG gel
2. Correctly place Pulse Ox probe
3. Correctly place NIBP cuff
4. Correctly place esophageal stethoscope
5. Correctly place temperature probe
6. Correctly place airway sampling line
7. Connect and deliver IV fluids at proper rate
8. Appropriately respond to patient physiologic changes during surgery and anesthesia.
9. Recognize and troubleshoot any monitor errors
10. Recognize and troubleshoot any anesthetic machine and circuit errors
11. Communicate effectively with team members.

Roles:

- A team of 4 anesthetists
- Dentist/ Dental Technician

Simulation Ground Rules:

- Scrubs, stethoscopes, name badges.
- Simulation is clinical time, same guidelines apply.
- Treat manikin like real patient.
- Simulation Time Outs Available.
- Vegas Rules Apply...What happens in simulation stays in simulation.

Appendix ER Drugs

ER Drug	Concentration	Dose	Route
Hypertonic Saline	7%	4ml/kg	IV
50% Dextrose	0.5g/mL	1mL/kg	IV slowly
Amiodarone	50mg/mL	5-10	IV, IT
Atipamezole	5mg/mL	0.1 (equal to dexmedetomidine vol)	IV,IM
Atracurium	10mg/mL	0.2, then 0.1 for addt'l boluses	IV
Atropine	0.54mg/mL	0.04 0.4 (PEA)	IV,IT,IO
Calcium Chloride	100mg/mL	150-350 (0.1mL/kg)	IV slowly
Calcium Gluconate	100mg/mL (45mEq/mL)	50-150 0.1-0.2 mEq/kg/hr	IV, IO slowly
Dexamethasone Sodium Phosphate	4mg/mL	1-2	IV
Diphenhydramine	50mg/mL	1-5	IV
Dobutamine	12.5mg/mL	2.5-10 μg/kg/min CRI	IV
Dopamine	40mg/mL	2.5-10 μg/kg/min CRI	IV
Doxapram	20mg/mL	1.1-2.2	IV
Edrophonium	10mg/mL	0.5	IV slowly
Ephedrine	50mg/mL	0.05-0.2	IV
Epinephrine	1mg/mL	0.01-0.02 (low) 0.1-0.2 (high)	IV, IT,IO
Esmolol	10mg/mL	0.05-0.1 mg/kg (bolus)-cats 0.2-0.5 mg/kg (bolus)-dogs 25-200 μg/kg/min (CRI)	IV
Flumazenil	0.01mg/mL	0.1 mg/kg (0.2mg/kg total dose)	IV(slowly),IT,IO
Furosemide	10mg/mL and 50mg/mL	2-8	IV
Glycopyrrolate	0.2mg/mL	0.01	IV or IM
Heplock	10unit/mL	As Needed to Flush	IV
Isoproterenol	0.2mg/mL	0.04-0.08 μg/kg/min (CRI)	IV
Lidocaine	20mg/mL	1-2 (dogs) 0.2-0.5 (cats)	IV,IT,IO
Magnesium Chloride	200mg/mL	30	IV slowly 5 min
Mannitol	200mg/mL	250-1000	IV,IO
Naloxone	0.4mg/mL	0.01-0.04	IV,IT,IO
Norepinephrine	1mg/mL	4mg in 1L LRS 0.5-4 μg/kg/min (CRI)	IV to effect
Phenylephrine	10mg/mL	1-3 μg/kg/min (CRI)	IV
Potassium Chloride	2mEq/mL	20mEq/L	IV slow drip
Procainamide	100mg/mL	5-10 (dogs) 2 (cats)	IV, IO, IT
Propranolol	1mg/mL	0.02-0.06 (dogs only)	IV slowly
Sodium Bicarbonate	84mg/mL or 1mEq/mL	1mEq/kg	IV,IO (not IT)
Solu-Delta Cortef	100mg and 500mg	30	IV
Solu-Medrol	62.5mg/mL	30-35	IV
Vasopressin	20unit/mL	0.1 U/kg Resuscitation 0.8U/kg	IV, IO, IT

References

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