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Propranolol Overdose: An Emergency Medicine Simulation Scenario

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Abstract

Simulation-based medical education is continually expanding and evolving to foster a better and more comprehensive learning environment. With particular regard to emergency medicine, the use of simulation in training has been shown to increase learners' knowledge and skills [1]. To a lesser extent, this has also improved patient outcomes [1]. Despite this evidence, the development of emergency medicine simulation training in a majority of residency programs is either not formalized or is still in its initial phases [2]. In this report, a simulation training session used to familiarize emergency medicine residents with the presentation, management, and treatment of a beta-blocker overdose, specifically propranolol, using a human patient simulator is described.

Categories: Emergency Medicine, Medical Education, Medical Simulation
Keywords: overdose, beta-blocker, simulation based medical education, propranolol, emergency medicine

Introduction

Propranolol is a sympatholytic non-selective beta-blocker used in the treatment of hypertension; it can be used in the treatment of anxiety and panic disorder. Signs and symptoms of toxicity are generally non-specific and may include coma, generalized tonic-clonic seizures, cardiac arrhythmias, and respiratory distress [3-4]. Beta-blocker overdose is not uncommon, given its widespread use. More than one-third of overdoses using anti-hypertensive medications have been attributed to beta-blocker intoxication with 1.5% of those cases being fatal if left untreated [5]. It is thus important for emergency medicine residents to familiarize themselves with the presentation and management of a beta-blocker overdose.

This technical report outlines a simulation teaching session developed for a group of postgraduate emergency residency trainees in the third and final year of their training program. The objectives of this report are to familiarize learners with the clinical presentation, investigation, and management of a patient with suspected propranolol overdose, and complications that may arise.

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Technical Report

Technical report

The simulation training session was conducted in a lab using a high-fidelity mannequin simulator, Gaumard Noelle S575 human patient simulator (Gaumard Scientific, Miami, FL).

Prior to the session, a stepwise, detailed scenario template developed by the Clinical Learning and Development Centre (CLDC), our in-house simulation laboratory, was filled by one of the clinical educators and authors on this paper (KA). The template was then submitted to the simulation laboratory technical staff, who then programed the mannequin and supplied required materials for the scenario's execution.

The scenario was prepared to be a team learning activity with two to four learners who would role-play various health professionals. However, the scenario can be adapted to be inter-professional if various learners, representing multiple disciplines, are included. As outlined below, the overall objectives of this session were explained during the pre-scenario briefing. During the pre-scenario briefing, the case was described and the roles of individual learners were identified.

In addition to the technical staff that operated the human patient simulator, two trained instructors executed the scenario. One instructor ensured that the technical staff adhered to the template, provided all supporting learning materials (Figure *1*), and used previous clinical experience to troubleshoot any possible deviations from the scenario template. The other instructor was given the role of a "scribe" and noted individual and team performances using a-priori developed checklists (Figure 2) for formative assessment and debriefing at the end of the scenario. Both instructors participated in the debriefing of the trainee(s).

Pre-Scenario

You are an emergency room physician in a tertiary-care hospital. A 28-year-old female arrives in the ER, brought in by her husband. She is unresponsive on arrival. Her husband found her in their bedroom along with an empty bottle of his propranolol. Her husband last saw her 5 hours prior when they ate dinner.		
History		
Allergies	None	
Medications	None	
Past Medical Hx	Depression	
Social Hx	Smoker	
Family Hx	Nil Significant	
Initial Vitals	T 36.2°C axillary / HR40 / BP70/30 / RR3 / SpO2 74% RA Patient is unresponsive on arrival	
HEENT	Pupils 3mm, equal, reactive to light; extra-ocular movements	
CNS	Eyes not open (E1); Incomprehensible sounds (V2); Withdrawal to painful stimuli (M4) = GCS 7	
Chest	Decreased air entry bilaterally in bases. Normal HS; S1 & S2	
Abdomen	Benign	
Expected Actions		
Place patient on telemetry		
Obtain IV access		
Administer 100% O2, non-rebreather mask		
Order EKG		
Order Labs: Electrolytes, CBC, BUN, Cr, Glucose, Ca, Mg and serum levels of acetaminophen, ASA & EtOH		
Administer IV Normal Saline Bolus		
Prepare for intubation		
Begin Scenario		
Objective 1: Airway/Breathing/Circulation		
Stage	Vitals	Expected Action
Intubated with appropriate or no agent given	T 37°C / HR35 / BP68/40	
Intubated and/or if given propofol	T 37°C / HR35 / BP50/30	
Objective 2: Circulation		
Intubated with appropriate agents given in objective 1	T 37°C / HR35 / BP68/40	Give normal saline bolus
Intubated with propofol given in objective 1	T 37°C / HR35 / BP50/30	Give normal saline bolus
If normal saline given	T 37°C / HR38 / BP70/40	Give 5mg glucagon IV
If glucagon given	T 37°C / HR45 / BP72/38	Consider atropine
If atropine given	T 37°C / HR50 / BP75/40	
If glucagon infusion not started	After 5 minutes: T 37°C / HR40 / BP68/35	Start glucagon infusion
Objective 3: Making the diagnosis		
Stage	Vitals	Expected Actions
Laboratory Results	Electrolytes, Ca, Mg, BUN, Cr – Na 140 / K 3.8 / Cl 97 / Ca 9.5 / Mg 2 / BUN 15 / Cr 1.3 Acetaminophin, ASA, EtOH – Nil Significant CBC – WBC 9 / Hgb 12/ Plts 400 Glucose – 4.8 EKG – Sinus Bradycardia (See Figure 1)	Identify bradycardia, hypotension and history and consolidate all factors together to solidify the diagnosis of propranolol overdose.
Objective 4: Managing Complications		

Stage	Vitals	Expected Actions
If no glucagon infusion started in objective 2	T 37°C / HR40 / BP68/35	Start glucagon infusion (3-5mg/kg bolus; 3-10mg/hr infusion)
If glucagon infusion started in objective 2	T 37°C / HR50 / BP75/40	
Patient begins to seize	T 37°C / HR65 / BP78/35	Administer IV benzodiazepines
After benzodiazepines patient stops seizing	T 37°C / HR60 / BP75/35	Request repeat vitals
Repeat Vitals	T 37°C / HR52 / BP75/30	
Objective 5: Managing Beta-Blocker Overdose		
Stage	Vitals	Expected Actions
Give high-dose insulin	T 37°C / HR50 / BP78/35	Administer insulin 1u/kg with D5/D10 infusion Also consider: Ca gluconate (30mls 10% solution) or CaCl (1ml 10% solution) via central line
Repeat vitals after insulin	T 37°C / HR52 / BP75/30	Obtain central access for vasopressors
Repeat Vitals after vasopressors	T 37°C / HR50 / BP90/40	
Alternative therapies	Consider alternative therapies: lipid emulsion and PDE inhibitors	
Scenario Conclusion (Endpoints)		
Stabilization and transfer to ICU if: Bradycardia is addressed Hypotension is addressed Seizure is resolved		

TABLE 1: A stepwise, detailed scenario template submitted to the simulation laboratory technical staff who programed the mannequin and supplied required material for the scenario.

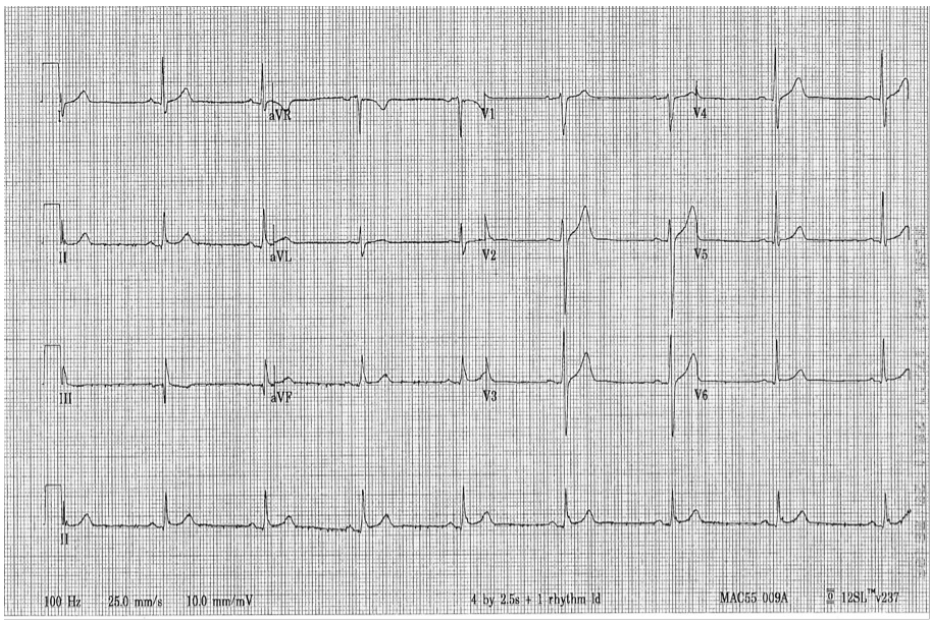

FIGURE 1: An electrocardiogram (EKG or ECG) demonstrating sinus bradycardia typically seen in a beta-blocker overdosed patient.

Scenario Assessment Checklist	Completed

History	Yes	No
Allergies		
Medications		
Past Medical History		
Social History		
Family History		
Physical		
HEENT		
CNS		
Chest		
Abdomen		
Expected Initial Actions		
Telemetry		
Obtain IV access		
100% O2 NRB		
Order EKG		
Order Labs		
Administer NS Bolus IV		
Prepare for Intubation		
Objective 1: Airway and Breathing		
Intubated with appropriate medications		
Objective 2: Circulation		
Normal saline bolus administered		
Glucagon 5mg IV administered		
Atropine administered		
Glucagon infusion started		
Objective 3: Making the diagnosis		
Obtained all ordered labs		
Correctly diagnosed as a beta-blocker overdose		
Objective 4: Managing Complications		
Glucagon infusion started if not completed in Objective 2		
IV benzodiazepines given to cease seizure		
Vitals repeated following benzodiazepines		
Objective 5: Managing beta-blocker overdose		
High dose insulin administered		
Vitals repeated after high dose insulin		
Vasopressors given for hypotension		
Vitals repeated after vasopressors		
Lipid emulsion and phosphodiesterase (PDE) inhibitors considered		
Conclusion		

Supportive care until ICU arrives		

TABLE 2: Checklist of objective criteria completed by trainee(s) to be used for formative assessment or completed by instructor for trainee(s) testing purposes.

Pre-briefing

Prior to the beginning of the scenario, a pre-briefing was held with the trainees. During the pre-briefing, a team lead for the case was identified. Any limitations of the simulation pertaining specifically to technical issues of the mannequin and resource availability were outlined and reviewed in detail. Additionally, the fiction contract – the agreement between participants and instructors to proceed as if the simulation was real, while simultaneously acknowledging it was not – was reviewed and a mutual understanding between the trainee and instructor was reached on any points of contention. Lastly, the trainees were notified as to the purpose of the session. Generally, most scenarios were strictly formative in nature, but there exists the possibility of using simulation scenarios as an evaluation tool using an objective based checklist, such as the one displayed in Table *2*.

Case

This simulation case involves a 28-year-old female patient presenting unresponsive to the emergency department in a tertiary-care hospital after being found by her husband in their bedroom. The patient was discovered with a bottle of her husband's propranolol lying nearby. Upon request by the trainee, information was provided around the patient's allergies, medications, social history, family history, and a past medical history of depression.

At the beginning of the scenario, the patient was connected to cardiac monitors with a full suite of vital signs provided indicating bradycardia and hypotension. The scenario is set in a resuscitation bay with a resuscitation cart, defibrillator, and airway equipment immediately accessible. Medications utilized in advanced cardiac life support and rapid sequence intubation was also on-hand. Additionally, glucagon and benzodiazepines were available. One or more confederates were recruited to play the part of a nurse or other health care professionals who assisted with any resuscitation measures directed by the trainee.

The scenario was completed in a stepwise fashion with the mannequin programmed to display pre-determined vital signs and symptoms that change as selected treatments were either initiated or overlooked by the trainee.

In order to facilitate a streamlined session for the trainee, an instructor completed a full run-through of the scenario prior to its implementation. This allowed identification of limitations of the simulation scenario as well as addressed technical issues. During the scenario, checklists were used which allowed instructors to assess trainees' performance and identify frame errors that may have occurred. The task of recording trainees' actions and critical points during the scenario was assigned to one instructor. A second instructor served as the overall lead for the session as well as the subsequent debriefing.

Debriefing

At the conclusion of the scenario, the trainee(s) were provided with a formal debriefing that was limited to a debriefer-to-learner ratio of no greater than 1:1. This imposed ratio limit ensured that trainees were encouraged to speak freely about any issues or problems that they may have faced during the course of the scenario. An in-house model developed based on frame discovery [6-7] and the 3D model of debriefing [8] was used in these sessions. The debriefing process aimed to solicit the trainee's thought process through an advocacy-inquiry technique. This allowed the identification of knowledge gaps and process errors.

Post-scenario didactics

Following the debriefing, a didactic session was conducted. This was used to address any knowledge gaps identified during the training session. Additionally, it enabled the trainee to consolidate knowledge gained as a result of the simulation exercise.

During this session, the pathophysiology of beta-blocker overdose was highlighted and other interventions the trainee should consider, specifically addressing the use of glucagon, high-dose insulin, and lipid emulsion therapy were explored.

Glucagon is a first line antidote in treating beta-blocker toxicity. It increases cAMP, subsequently aiding myocardial contractility and providing both inotropic and chronotropic effects [9]. Phosphodiesterase (PDE)

inhibitors employ a similar method, and while not fully understood, are thought to decrease cAMP breakdown.

In recent years, high-dose insulin therapy has emerged as a treatment for poison-induced cardiac shock. Its main mechanism lies in its inotropic effect, thought to result from increased intracellular glucose transportation within cardiac muscle. In particular, this inotropic effect occurs without increasing myocardial oxygen demand [10].

Lipid emulsion therapy, while not as effective in beta-blocker poisoning as in calcium channel blocker overdose, is thought to provide a lipid sink to surround the lipophilic molecule and render it ineffective, while at the same time providing a substrate for myocytes [11].

Discussion

The management of beta-blocker overdose is complex and, if inadequately addressed, may lead to significant mortality. While there may be a wide range of clinical presentatons of beta-blocker toxicity, the differential diagnosis of a hypotensive and bradycardic patient is narrow and thus this condition should be considered in the ER [12]. It is thus important that physicians in an emergency department be aware of the signs, symptoms, treatments and management plan of patients experiencing beta-blocker overdose.

The specific learning objectives of this case are premised mainly on:

1. Airway management of the comatose patient;

2. Addressing hypotension and bradycardia in the setting of beta-blocker toxicity; and

3. Controlling seizures arising from propanolol toxicity

Using a stepwise algorithm to develop the scenario allows the simulation to change in a pre-determined manner in response to trainee decisions. An instructor run-through ensures that the case is not excessively demanding of the trainee, as well as facilitates the identification of the scenario's limitations. Lastly, a formalized debriefing model as well as a post-scenario didactic session allows instructors to unearth and address trainee's knowledge gaps and process errors.

Conclusions

Teaching emergency medicine trainees to identify, treat, and manage the complications of beta-blocker toxicity is an important task. Using simulation to facilitate this may be an effective method of teaching. Research shows that the ability to use simulation to repeatedly practice a skill helps trainees improve on and excel at that skill in the future [13]. Here, a stepwise algorithm developed to augment the completion of a propranolol overdose case simulation is described. Additionally, an integrated teaching session incorporating simulation and didactics with components of debriefing used to train emergency medicine residents is outlined.

Additional Information

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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