Kestler A , Kestler M, Morchi R, !!SAEM!! Severe Malaria Simulation Scenario. MedEdPORTAL; Available from: www.aamc.org/mededportal ID=1740

I. TITLE: SEVERE MALARIA SIMULATION SCENARIO

II. TARGET AUDIENCE: Medical Students, Residents, Infectious Diseases/Critical Care Fellows, and Medical School Faculty (Emergency Medicine, Internal Medicine, Infectious Diseases, Critical Care)

III. LEARNING OBJECTIVES

Objective 1: Recognize high-risk groups for malaria

Any traveler to an endemic area in the year prior to presentation should be considered at risk for the disease (6). Immigrants originally from endemic countries are at particularly high risk, because they are much less likely to take malaria prophylaxis when they travel to visit family abroad (16).

Objective 2: Establish a definitive or presumptive diagnosis of malaria

Fever is the most common initial manifestation of malaria, accompanied variably by headache, myalgias, jaundice, vomiting, abdominal pain, cough, and diarrhea (4). The non-specific nature of symptoms in early, uncomplicated malaria necessitates a focused differential diagnosis that includes other life-threatening infectious diseases that benefit from prompt antibiotic treatment. Thick and thin blood smears are the backbone of laboratory diagnosis. Blood smears, however, are not always immediately read by trained personnel, and false negatives occur. A presumptive diagnosis of malaria is warranted in any seriously ill patient who is at risk for malaria and treatment should never be delayed in the wait for a positive blood smear (4).

Objective 3: Identify and treat the complications of severe malaria

Anti-malarial should be initiated on the basis of a presumptive diagnosis in any seriously ill patient who is at risk for malaria (4) Coma and acidosis are the most common manifestations of severe malaria in adults. Renal failure, seizures, hypoglycemia, severe malaria, disseminated intravascular coagulation (DIC), and non-cardiogenic pulmonary edema (ARDS) are other important complications of severe malaria. The most important step in managing the complications of severe malaria is the prompt initiation of anti-malarial drugs (4). All complications of malaria should be treated as they would for any critically ill patient, with the caveat that malaria patients are more prone to fluid overload than septic patients and thus and require cautious fluid administration (12).

Objective 4: Know the treatment for severe malaria and its complications

In malaria endemic regions, intravenous quinine sulfate remains the first-line treatment for severe malaria. Because intravenous quinine is not available in the US, quinidine gluconate is the drug of choice. Quinidine is a more effective anti-malarial than quinine and is less likely to cause hypoglycemia, but is more cardiotoxic and thus requires continuous electrocardiographic monitoring (6). In cases of severe malaria with elevated parasitemia (>10% of red blood cells on a thin smear) that do not respond promptly to anti-malarials, one may consider an exchange transfusion, although there is no strong clinical evidence to support its use (6,15)

Objective 5: Identify resources for assistance in the management of malaria

Emergency medicine physicians and other critical care providers should know what resources are rapidly available to assist in the management of malaria. The Sanford Guide and other pocket manuals contain dosing information, as does the website of the Centers for Disease Control (CDC) at: www.cdc.gov/malaria. A CDC malaria specialist is also available 24-hours a day for telephone consultations (5). Physicians taking care of a patient with possible severe malaria

should seek infectious disease consultation, and may also ask their inpatient pharmacist for dosing assistance.

B) Critical Actions Checklist

The critical actions to follow are listed according to the 5 clinical states of the patient (see Case Narrative below.)

Clinical State #1: Presentation

The critical actions are asking the appropriate travel history, recognizing the patient is at high-risk for malaria (Objective 1), and ordering the appropriate tests for malaria and other diseases in the differential diagnosis (Objective 2). An astute provider might recognize the tachypnea to be a sign of acidosis in severe malaria (Objective 3) and order empiric therapy (Objective 4). Additionally, the participant should consider other life-threats in the differential diagnosis (and start empiric treatment): meningitis (steroids, ceftriaxone, vancomycin), severe typhoid (ceftriaxone), tick typhus or relapsing fever (doxycycline).(Objective 2)

Clinical State #2: Coma

The critical actions are identifying seizure, coma, and acidosis as a manifestation of severe malaria (Objective 3). Also, a finger-stick blood glucose should be checked as a potential cause of the seizure and as potential complication of severe malaria. At the minimum, even without initially recognizing malaria, the participant must provide appropriate supportive care for seizure, coma, and acidosis, including endotracheal intubation for airway protection (Objective 3). If it has not yet been done in Clinical State #1, the participant should start intravenous quinidine empirically (Objective 4), and request help from a specialist (Objective 5). Also, if not done in Clinical State #1, the participant should start empiric treatment for other life threats in

the differential diagnosis: meningitis (steroids, ceftriaxone, vancomycin), severe typhoid (ceftriaxone), tick typhus or relapsing fever (doxycycline). (Objective 2)

Clinical State #3: Torsades

Critical actions include recognizing prolonged QT interval and Torsades de Pointes as complications of quinidine therapy, in setting of patient's self treatment with a QT prolonging macrolide. The other critical actions include performing CPR and defibrillation, administering magnesium, and temporarily discontinuing (or slowing) the quinidine infusion. (Objective 4)

Clinical State #4 (optional): Severe Acidosis/ARDS

Critical actions include asking for additional expert consultation (Objective 5), considering exchange transfusion (Objective 4), and optimizing fluid management with use of central line and central venous pressure monitoring, given that overly aggressive fluid resuscitation may worsen outcomes in severe malaria.(Objective 3.) Optimal supportive care is also likely to include the use of vasopressors, although epinephrine should be avoided. (11)

Clinical State #5: Stabilization

Critical actions include continuing anti-malarial therapy, and giving report to the admitting intensive care team: The latter will give participants the opportunity to review all critical actions taken as they summarize the case (Objectives 1 through 5).

IV. ENVIRONMENT

A. Lab Set Up: The setting is a simulated emergency department resuscitation room complete with monitors, a code cart, and standard intravenous equipment and medications. The control room is located behind a one-way glass wall, and has a listen-only audio connection to the scenario room. Intercom phones allow

participants to call the control room to speak with "consultants," and "ancillary services." The in-scenario facilitator (the RN) and the control-room lead instructor are also linked by walkie-talkie radios with earphones. Observers may watch the scenario from an adjacent classroom with audio and video feeds from the scenario room.

B. Manikin Set UP: The simulated emergency department is equipped with the METI Emergency Care Simulator (METI ECS), a high-fidelity patient simulator that blinks, breathes, has palpable pulses, and speaks through a speaker linked to an instructor in the control room. (Additional information is available from Medical Education Techonologies, Inc, Sarasota, FL, www.meti.com.) The software of METI ECS permits the creation of multiple physiologic states, which can be programmed to worsen with time and to respond to therapeutic maneuvers, or which can be manipulated directly by the instructor.

C. Props:

- **i.** Airway cart with equipment for endotracheal intubations
- **ii.** EKG machine and the following EKGs: a) sinus tachycardia, b) sinus tachycardia with a prolonged QT, and c) rhythm strip with Torsades de Pointes.
- **iii.** "Portable X-ray Machine": Any large piece of equipment on wheels, or large cart may be used. X-rays including: normal female chest X-ray, normal intubated female chest X-ray, and intubated female chest X-ray with non-cardiogenic pulmonary edema.

iv. Medications: Medication and fluid infusion bags with tubing including (but not limited to): normal saline, magnesium, quinidine, ceftriaxone, vancomycin, and dopamine. Crash cart and rapid-sequence intubation medications including lorazepam, etomidate, succinyl choline, glucose, etc.

D. Distractors: None. However, for added complexity, the patient may be 6-months pregnant (see Case Narrative below.)

V. ACTORS

A. Roles

i. Nurse (RN): The nurse is played by nurse instructor who is wired by earphone to the lead instructor. Based on participant requests, the RN will place the patient on a monitor, start IV lines, monitor CVP, and administer medications. With radio cues from the head instructor, the RN may give clues to the participants that are not easily simulated by the mannequin, e.g. the presence of dry mucous membranes.

ii. EKG and X-ray technicians, respiratory therapist, and pharmacist: These roles may all be filled by a single person who remains in the control room, and enters the scenario room only for a designated action: perform an EKG, take an X-Ray, deliver medications, adjust ventilator settings, etc. This person also answers phone calls to the control room as the operator or ancillary service provider. This role may be filled by any one with basic medical training (or in training) and who has been appropriately briefed on the scenario.

iii. Patient (in control room): An assistant provides the voice for the manikin from the control room. This person may also enter the scenario as a family member when the patient is unconscious.

iv. Consultants (in control room, speaking by intercom phone): This role is played by the lead instructor (MD) who remains in the control room. Depending on the level of the participants, the lead instructor may give a varying degree of guidance as an infectious disease consultant, as the admitting intensive-care physician, etc.

v. Participant (resident, fellow, or senior student): The primary participant will make all clinical decisions in the scenario.

vi. Secondary Participants: Other participants, typically students (RN or MD), will assist with procedures (IV or central lines, Foley catheters, CPR, etc) and be variably engaged in calling consultants, ordering studies or services, or looking up therapeutic guidelines online.

VI. CASE NARRATIVE

A. Scenario Background

Triage Note

A 34 year-old woman presents to the emergency room with the chief complaint of fever and headache for 3 days. She has vomited three times today and has had some loose stool as well.

Past Medical History

Childhood asthma

Denies prior tuberculosis or exposure

Medications

Tylenol for fever

Erythromycin x 2 days (left over from her son's recent throat infection)

Social History

No tobacco, no alcohol, no illicit drugs

She is originally from Nigeria, but has lived in the United States for the last 15 years

Option for very advanced simulation participants: Patient can be 24 weeks pregnant, giving participants the opportunity to learn about the complications of malaria in pregnancy. This will necessitate a broader differential diagnosis to include preeclampsia, abruptio placenta, and fetal demise with sepsis.

B. Initial Scenario Conditions: Clinical State #1: Presentation

Initial words "Doctor, I feel terrible. I am very sick. My head hurts and I keep vomiting."

Then: "I started feeling achy and feverish about 3 days ago, with a bad headache. Yesterday, I started vomiting non-stop. I can't keep anything down. My bowel movements have been runny as well.

Travel History *(if asked, if not, husband will eventually volunteer information at end of state 1 or beginning of state 2)*

Returned 7 days ago from Nigeria, where she spent three weeks to attend a family funeral in a rural area in the North of the country. She did not take malaria prophylaxis. "I had malaria when I was a kid and it was never serious. Also the medicine is very expensive."

Review of Systems *(if asked)*

Shortness of breath, without cough

Dark Urine, no dysuria or frequency

No vaginal bleeding, or discharge

Diffuse abdominal pain, worse with vomiting

Stiff neck

Diffuse myalgias

Family History *(if asked)*

Relatives with sickle cell and some other condition that "can cause your blood cells to break"

Physical Exam

VS: HR 120, RR 34, BP 92/64 Temp 38.7 oral, Pulse Ox 96% (on simulation monitor)

General: Ill appearing, retching occasionally.

HEENT: Dry mucous membranes. Anicteric sclera.

Neck: Diffuse soft tissue tenderness, no frank meningismus

Chest: Clear to auscultation bilaterally, increased work of breathing

One sentence dyspnea: patient pauses to catch her breath after each short sentence.

CV: Tachycardic, regular, 2/6 systolic ejection murmur, heard best at left upper sternal border, no radiation

Abdo: Diffuse mild to moderate tenderness to palpation, without guarding or rebound. No hepato-splenomegaly.

Ext: Cool, normal peripheral pulses, cap refill approx 2 seconds

Neuro: Alert, oriented x 3, but slow to respond to questions.

Ancillary Tests *(if requested, but most lab results not available until Clinical State #2)*

Chest X-ray: Clear

EKG: Sinus Tachycardia (ST) or ST with mildly prolonged QT.

Bedside finger-stick glucose: 65

CBC: hematocrit 36, white blood cell count 12, platelets 125

Urine: +2 hemoglobin, + bilirubin, trace ketones, 0-5 RBCs on microscopy.

Chemistry panel: Sodium 135, Potassium 4.9, Chloride 106, Bicarbonate 7, BUN 28, Creatinine 1.5, Glucose 65

Lactate: 5.0

Arterial Blood Gas: 7.2/30/75

Bilirubin: Total 2.5. Indirect: 2.0 Direct: 0.5

C. Scenario Evolution: Clinical States 2-5

Clinical State #2: Seizure and Coma

The patient seizes for 5 minutes *(she will stop sooner if anti-convulsants are given).*

If glucose not checked and given during Clinical State #2, patient will seize again, and continued to seize if glucose is not given. If glucometry checked for first time here: 50.

Patient does not emerge from post-ictal state. *The husband of the patient (optional) may arrive at this time to give a travel history if it was not obtained in Clinical State #1.*

Physical exam

Unchanged, except for the following

VS: BP 90/60. HR: 124 RR: 18 Temp: 39.0 (rectal) Pox 86%

Monitor: Sinus Tachycardia

General: Unresponsive

Resp: Gurgling respirations, bilateral rales

Neuro: Pupils 5 mm, minimally responsive

Upgoing toes bilaterally

No spontaneous movement

Moans and non-purposeful movement with painful stimulation

Ancillary Tests *(if requested)*

Most labs ordered during clinical state #1 return here.

Chest X-ray: Bilateral patchy infiltrates: Fluid overload, aspiration pneumonitis, or acute lung injury.

Arterial Blood Gas #2: 7.1/45/60

Arterial Blood Gas #2A (if post-intubation & hyperventilation): similar to initial ABG in Clinical State #1: 7.2/30/75

Thin Blood Smear: Not immediately available.

Clinical State #3: Torsades *(If quinidine is not given, patient will bypass Clinical State #3 and go to Clinical State #4)*

Patient will go into Torsades de Pointes 10-15 minutes after quinidine is given. Patient will briefly return to Clinical State# 2 if defibrillated, but will return quickly to Torsades. The patient will not emerge from Clinical State #3 until magnesium is administered.

Physical Exam

Vital Signs: No pulse, no blood pressure, no spontaneous respirations

Monitor: ventricular tachycardia vs. Torsades

Rhythm strip on close examination: Torsades.de pointes

Ancillary Tests

Post arrest EKG: Sinus Tachycardia with prolonged QT interval

Clinical State #4 (optional): Severe Acidosis/Deterioration

This state may be avoided for participants who manage states 1, 2, and 3 appropriately. Alternatively, those progressing through states 1, 2, and 3 easily, may be presented with state 4 as an extra challenge.

Hypotension develops and tachycardia worsens. Oxygenation will worsen as ARDS develops. The patient will improve with continued supportive care (with judicious fluid use), continued administration of anti-malarials, and possibly an exchange transfusion. For very advanced simulation participants, a transfusion reaction may be added to scenario.

Physical exam

Unchanged from Clinical State #2, with the following exceptions:

VS BP 82/54 RR Ventilated HR 130 Temp 38.0 (rectal) Pox 92% on 100%

Skin: Mottled, cool extremities ("Nurse" Instructor Comment)

Lungs: Occasional rales, otherwise clear to auscultation

Ancillary Tests

ABG: 7.0/33/75

Lactate: 7

Blood Smear Returns: Multiple intra-cellular ring forms. Parasitemia: 12%

Clinical State #5: Stabilization

Here most physiologic parameters return to those of Clinical State #2. A family member may appear asking for an explanation. The patient will be prepared for admission to the intensive care unit.

Physical exam

Unchanged from Clinical State #2, with the following exceptions:

VS BP 100/72 RR Ventilated HR 108 Temp 37.8 (rectal) Pox 96% on 100%

Skin/extremities: Normal capillary refill

Lungs: Clear to auscultation

Neuro: Non-purposeful movements when stimulated, occasional cough on ventilator

Ancillary Tests

ABG: 7.3/33/80

VII. INSTRUCTOR NOTES

A. Tips: The scenario and debrief is expected to last approximately one hour. At least 30 minutes, and up to 60 minutes, is necessary to set up the scenario, depending on the type of simulation manikin used. In general, it is preferable not to let the patients die, and have the nurse or an external consultant provide the necessary guidance to keep the patient alive. This will allow simulation participants to experience the whole case and learn more about severe malaria. The lead instructor may modify some physiologic parameters, such as oxygen saturation, SVR, and heart rate, to make the patient improve or worsen according to the interventions chosen by participants. Because a lumbar puncture is not practical with the METI manikin, it is recommended participants never be given the opportunity due to patient acuity, or at the end of the case, the ICU team can offer to do the LP upstairs.

B. Tips to Actors: The primary direction of actors occurs via radio and earpiece to the in-scenario facilitator (the nurse instructor.) The nurse may then be cued to report on findings that the manikin is unable to simulate (seizing, for some manikins). In case

certain instructions or orders from the participants are missed, the nurse instructor may clarify participant orders. Additionally, the nurse instructor may answer yes/no questions from the lead instructor by a thumbs up/thumbs down visible through the one-way glass. Instructions to the actors playing the ancillary staff are usually quite simple: "Please go do the EKG, take the X-ray, adjust the ventilator settings, etc."

C. Scenario Programming:

i. Optimal management: In an optimally managed case, participants will ask the appropriate travel history, recognize the potential for severe malaria, solicit help from consultants, and start empiric therapy for meningitis and severe malaria. Again, in the optimal case, participants will immediately recognize Torsades as a complication of quinidine therapy, and administer magnesium.

ii. Potential Complications: The Torsades from QT prolongation in the setting of quinidine and outpatient macrolide therapy is a key part of the case. For those having great facility with the basic critical actions, the patient can continue to worsen until an exchange transfusion is given, and may then develop a transfusion reaction. For advanced participants, the patient may be made to be 24 months pregnant, adding complexity to the case and additional considerations in the differential diagnosis (eclampsia). Also for advanced participants, the infectious disease consultant may not be available, or available only on a very bad cell phone connection, thus forcing the participants to look up malaria treatment guidelines on the CDC website, or to call the CDC directly.

iii. Potential Errors: Failure to ask a travel history or suspect malaria will lead to rapid deterioration to Clinical State #4. Eventually, a family member can appear and volunteer the travel history in order to redirect the participant toward the right diagnosis. Also, if the participant fails to recognize Torsades and a prolonged QT and gives amiodarone instead of magnesium, the Torsades may become harder to treat in the setting of another agent which prolongs the QT.

VIII. DEBRIEFING PLAN

A. Debriefing method: Group debrief is recommended with the participants and the observers watching the live feeds from the classroom. All should be given an opportunity to comment on what went well and what did not go well in the case. The debriefing includes general background information on malaria and then a more detailed recount of the case according to the learning objectives and critical actions.

B. Background: Malaria accounts for over 1 million deaths per year. The greatest burden of malaria morbidity and mortality occurs in children under 5 years of age in Africa (1). Travel and migration increasingly transport malaria to the US and other industrialized countries, up to 30,000 cases per year by some estimates (2). In 2005, surveillance from the Centers for Disease Control identified 1528 cases of malaria in the US, a 15% increase from the previous year, and the greatest number since 1980 (3). Plasmodium falciparum, the species responsible for severe malaria, accounted for 48% of the cases, and caused all 7 fatalities (3). Severe malaria refers to malaria with signs of end organ dysfunction, as manifested by coma, pulmonary edema, renal

failure, circulatory collapse, or severe anemia (4). In general, 5% of imported cases progress to severe malaria, which in turn carries 20% mortality (2).

In non-endemic countries, malaria poses a significant challenge to medical education. Despite its worldwide importance, malaria is uncommonly encountered by medical trainees and physicians in practice. It is a complex and lethal condition with the potential for rapid deterioration from non-specific fever to multi-organ failure. Managing malaria thus requires time-critical actions, often on the basis of a presumptive diagnosis (4). Unfortunately, delays in diagnosis are common (3,5). One can also suspect that discontinuation of quinidine as an emergency anti-arrhythmic drug further reduces prescribing experience with the only available treatment for severe malaria in the US. Lack of physician familiarity with the diagnosis and treatment of malaria contributes heavily to preventable malaria deaths in non-endemic countries (3,5, 6, 7).

C. Debrief According to Learning Objectives: To follow are the complete learning objectives, expanded from the summary version presented above.

Objective 1: recognize high-risk groups for malaria

Any traveler to an endemic area in the year prior to presentation should be considered at risk for the disease(6) Immigrants originally from endemic countries are at particularly high risk, because they are much less likely to take malaria prophylaxis when they travel to visit family abroad (16). Plasmodium falciparum malaria presents within 3 months of exposure 98% of the time, but usually presents shortly after the incubation period of 9-18 days (6).

Objective 2: Establish a definitive or presumptive diagnosis of malaria

Establishing the diagnosis of malaria requires first establishing the patient is at risk (Objective 1). Many patients who later develop severe malaria are initially misdiagnosed (3,6,7,16). Diagnosing malaria also requires an understanding of the protean clinical manifestations of early, uncomplicated malaria. Fever is the most common, often accompanied by headache and myalgias (4). Jaundice, vomiting, abdominal pain, cough, and diarrhea may also occur, creating a broad differential diagnosis in the returned traveler. Other life-threatening infectious diseases that benefit from prompt antibiotic treatment should be considered, such as bacterial meningitis, typhoid, typhus (all kinds), leptospirosis, plague, and relapsing fever.

Thick and thin blood smears are the backbone of diagnosis. Although the thick smear is considerably more sensitive, many centers lack a technician skilled in its reading. In the middle of the night or on the weekend, a timely reading of a thin smear may be difficult as well in smaller hospitals. Furthermore, a thin smear may yield a false negative in cases of low parasitemia, in particular if the patient was taking malaria prophylaxis, or was previously treated with an agent that has some activity against malaria, such as clindamycin or doxycycline. Presumptive therapy should be initiated in any seriously ill patient who is at risk for malaria (4) Other laboratory findings in malaria that may help narrow the differential diagnosis include thrombocytopenia (very common, but usually mild), hyperbilirubinemia (unconjugated predominant), and hemoglobinuria. The latter accounts for what has been described as “Coca-Cola” urine (4).

<u>Objective 3: identify and treat the complications of severe malaria</u>

Coma and acidosis are the most common manifestations of severe malaria in adults. Renal failure, seizures, disseminated intravascular coagulation (DIC), and non-

cardiogenic pulmonary edema (ARDS) are other important complications of severe malaria. Hypoglycemia and severe anemia occur more frequently in children (14). Hypoglycemia may pass unnoticed because the seizures and altered mental status are typical manifestations of cerebral malaria. Acidosis is associated with hyperlactatemia in about 50% of cases. Epinephrine is relatively contra-indicated based on a theoretical basis because epinephrine increases lactate production more than other pressors (11). There are some similarities between sepsis and severe malaria (10), but the conditions are different in that tissue hypoperfusion is due more to the microcirculatory pathophysiology of malaria rather than to relative hypovolemia or hypotension (13). As a consequence, patients with severe malaria are vulnerable to fluid overload, particularly if acute lung injury is present (12). Pregnant women are at particularly high risk for complications in severe malaria. Parasite infiltration of the placenta leads to low-birth weight, intra-uterine fetal death and premature labor (4).

The most important step in managing the complications of severe malaria is the prompt initiation of anti-malarial drugs. Hypoglycemia should be detected and treated, and at times may require a continuous infusion of glucose. Seizures not due to hypoglycemia should be treated with standard anti-convulsants (4). Prompt initiation of anti-malarials, and to a lesser extent judicious fluid resuscitation, is essential to reversing acidosis. Endotracheal intubation and mechanical ventilation may be necessary if the patient progresses to ARDS or if the patient is comatose and cannot protect the airway. The renal failure, if severe, rarely responds to diuretics, and often requires continous hemofiltration which tend to be better tolerated than intermittent hemodialysis (4.)

Objective 4: Know the treatment for severe malaria and its complications

In malaria endemic regions, intravenous quinine sulfate remains the first-line treatment. Quinine causes hypoglycemia and is often infused with 10% dextrose prophylactically. Artemisinin compounds are equally effective in severe malaria, can be given intra-muscularly or rectally, and have been incorporated into the severe malaria protocols of the World Health Organization. Because intravenous quinine and artemesinins are not available in the US, quinidine gluconate is the first-line drug: Quinidine is a more effective anti-malarial than quinine, but is more cardiotoxic and thus requires continuous electrocardiographic monitoring (6). Patients taking other drugs, such as macrolides and fluoroquinolones, that prolong the QT interval are at higher risk for cardiac toxicity. There is no role for oral therapy in the initial treatment of severe malaria. Oral quinine, doxycycline, clindamycin, mefloquine, atovaquone-proguanil, and sulfadoxine-pyremethamine (Fansidar) are used in treating uncomplicated malaria or as second drugs in the continuation phase of treating severe malaria. Chloroquine is only indicated if it is certain the patient traveled to an area with chloroquine-sensitive malaria (Caribbean, Central America, Middle East). If a hospital does not have access to intravenous quinidine, one should transfer the patient immediately to a center that does, and should consider a temporizing dose of oral quinine or mefloquine, or an intravenous dose of clindamycin or doxycline. None of the drugs to treat severe malaria cause hemolysis in patients with G6PD deficiency.

In cases of severe malaria with elevated parasitemia (>10% of red blood cells on a thin smear) one may consider an exchange transfusion. There are no rigorous clinical trials to support this practice, however case reports of its success abound. The procedure is best

undertaken with electrocytopheresis (red blood cell separation), and re-infusion of plasma and platelets(6,15).

Objective 5: Identify resources for assistance in the management of malaria

Emergency medicine physicians and other critical care providers should know what resources are rapidly available to assist in the management of malaria. The Sanford Guide and other pocket manuals contain dosing information, as does the website of the Centers for Disease Control (CDC) at: www.cdc.gov/malaria. A CDC malaria specialist is also available 24-hours a day for telephone consultations (5). Physicians taking care of a patient with possible severe malaria should seek infectious disease consultation, and may also ask their inpatient pharmacist for dosing assistance.

D. Debriefing According to Critical Actions: To follow is a recap of the critical actions by clinical state, as linked to the learning objectives.

Critical Actions for Clinical State #1: Presentation

1) Asking travel history of patient (or family) and recognizing patient is at high risk for malaria (Objective 1)
2) Formulating differential diagnosis and ordering blood smears and blood cultures. Performing lumbar puncture and or covering empirically for meningitis (Objective 2)
3) Anticipating complications of malaria: checking glucose and renal function; providing supportive care (oxygen, IV access, gentle hydration) (Objective 3)
4) Ordering of appropriate anti-malarial drug, quinidine (Objective 4).
5) Asking for help: infectious disease consultation, CDC website (Objective 5).

Critical Actions for Clinical State #2: Coma

1) Endotracheal rapid sequence intubation, mechanical ventilation with relative hyperventilation for acidosis, and sedation (Objective 3)
2) Administer anti-malarial drug, if not done in Clinical State# 1: Loading dose of quinidine 10 mg salt/kg (or 6.25 mg base/kg) over 1 hour. (Objective 4) The participant will be prompted to administer the drug, in order for scenario to progress to Clinical State #3.
3) Use fluid resuscitation cautiously. Overuse will worsen oxygenation. Appropriate use will be best guided by placing a central line, and obtaining a central venous pressure. (Objective 3)

4) Treat seizures appropriately: glucose, anti-convulsant (Objective 3)
5) Solicit expert opinion/consultation if not done in Clinical State #1 (Objective 5)
6) Inform family member (husband) of situation
7) Optional: empiric therapy for other severe infections if malaria smear result not yet available and if CSF result not yet available: Ceftriaxone, Vancomycin, dexamethasone for bacterial meningitis, ceftriaxone +/- steroids for severe typhoid, and doxycline for other travel related potential pathogens (leptospirosis, relapsing fever, typhus—all forms, and plague)

Critical Actions for Clinical State #3: Torsades

1) CPR and defibrillation
2) Recognize torsades de pointe as complication of quinidine therapy (patient was previously on a macrolide) (Objective #4)
3) Administer magnesium bolus, 2 grams over 1-2 minutes, then start continuous infusion.

Critical Actions for Clinical State #4 (optional): Severe Acidosis/Deterioration

1) Ask for help: malaria expert at CDC (Objective 5)
2) Initiate vasopressors: Dopamine or norepinephrine preferred over epinephrine in malaria (Objective 3)
3) Initiate exchange transfusion at CDC's recommendation, manual or with erythropheresis (Objective 4)
4) Continued supportive care, with monitoring of central venous pressure to avoid fluid overload and worsening pulmonary edema, and with ventilator settings to continue compensatory respiratory alkalosis. (Objective 3)

Critical Actions for Clinical State #5: Stabilization

1) Continued Sedation
2) After loading dose of quinidine, initiate continuous infusion at 0.02 mg salt/kg/min for 24 hours. (Objective 4)
3) Reserve ICU bed, and call up patient to ICU team.
4) Update family on status of patient

IX. PILOT TESTING AND REVISIONS

A. Numbers of Participants and Pilot Run: 18 participants (both direct, and classroom observers) have gone through the scenario. The first trial run in which the patient was pregnant significantly mislead the participants. They focused on the

possibility of pre-eclampsia instead of eliciting the possibility of malaria through a travel history. It was thus decided to avoid pregnancy as a complicating factor for the majority of participants. This problem may be avoided if the patient or a family member volunteer the travel history early in the case.

B. Performance Expectations and Management Mistakes: Most participants, whatever the level, should suspect malaria early in the case. Given the infrequent use of quinidine, few participants (except the most advanced) are expected to be familiar with its complications. However, it is expected that all participants will learn to provide the appropriate supportive care and call for outside help from consultants as needed.

C. Evaluation Form: See Appendices A and B

X. AUTHORS AND AFFILIATIONS

Andrew Kestler, MD, MBA, DTMH*

Mary Kestler, MD, DTMH**

Ravi Morchi, MD*

*Division of Emergency Medicine, University of Colorado Denver School of Medicine

**Division of Infectious Diseases, University of Colorado Denver School of Medicine

Corresponding Author:

Andrew M. Kestler, MD, MBA, DTMH

Assistant Professor, Division of Emergency Medicine

Director, Global Health Track

University of Colorado Denver School of Medicine

12401 E. 17th Avenue, B215

Aurora, CO 80045

720-848-6777

Andrew.kestler@ucdenver.edu

Funding Sources: None

Acknowledgments:

Work Education and Lifelong Learning Simulation (WELLS) Center

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APPENDIX A: Evaluation Form for Severe Malaria Simulation Case

1) Please check your level of participation:

____Observer

____Participant/care provider

2) Your current position (please check one):

_____Medical Student: MS1

_____Medical Student: MS2

_____Medical Student: MS3

_____Medical Student: MS4

_____Nursing Student (undergraduate)

_____Nursing Student (graduate)

_____Nursing Instructor/Faculty

_____Other: please specify_____

_____Resident: PGY 1

_____Resident: PGY 2

_____Resident: PGY 3

_____Resident: PGY 4

_____Fellow

_____SOM Faculty

3) For Residents, Fellows, and SOM Faculty, please check your specialty:

_____Emergency Medicine

_____Family Practice

_____Internal Medicine

_____Pediatrics

_____Other: please specify_____

4) Prior to this simulation, have you been taught about malaria in your training?

_____Yes

_____No

5) Considering all ways you have been taught about malaria (including today's simulation scenario) please rate each of these teaching methods for effectiveness by checking the appropriate box.

Teaching Method	**Not effective**	**Minimally Effective**	**Moderately Effective**	**Very Effective**	**Never was taught about malaria by this method**
Lectures or conferences					
Problem-based learning sessions					
Direct contact with malaria patient & bedside teaching					
Simulation-based learning with actor					
Simulation-based learning with mannequin					
Other, please specify_____					

6) Which teaching method did you find most effective in teaching malaria (please circle one):
   a. Lectures or conferences
   b. Problem-based learning sessions
   c. Direct contact with malaria patient and bedside teaching
   d. Simulation-based learning with actor
   e. Simulation-based learning with mannequin
   f. Other, please specify_____
   g. Insufficient experience to judge/no previous teaching on malaria

7) Prior to the malaria simulation scenario, had you previously been exposed to simulation based learning in your medical training (please circle one)
   a. Yes, ACLS/ATLS/BLS/PALS only
   b. Yes, ACLS/ATLS/BLS/PALS and other: please specify:_____
   c. Yes, other: please specify:_____
   d. No

5) According to some experts, high-fidelity mannequin-based simulation is superior to other teaching methods (such as problem-based learning) in the teaching of life-threatening emergencies. Do you agree with this statement (please circle one):

Strongly disagree	Disagree	Agree	Strongly agree	Not sure or insufficient experience to judge

6) Did the simulation exercise teach you anything new about malaria?
    a. Yes
    b. No

7) In which of the following areas did you learn something new about malaria? (please circle all that apply)
    a. Identification of high-risk groups for malaria
    b. Making a diagnosis of malaria
    c. The complications of severe malaria
    d. The treatment of severe malaria
    e. Complications related to the treatment of severe malaria
    f. Resources available for assistance in treating severe malaria

8) "The simulated malaria case will improve my ability to diagnose malaria." Do you agree with this statement? (please circle one):

Strongly disagree	Disagree	Agree	Strongly agree	Not sure or insufficient experience to judge

9) "The simulated malaria scenario will improve my ability to treat severe malaria." Do you agree with this statement? (please circle one)

Strongly disagree	Disagree	Agree	Strongly agree	Not sure or insufficient experience to judge

10) What could be done to improve the simulation?

11) Additional Comments:

APPENDIX B: Knowledge Test for Severe Malaria Simulation Case

1) Name a very high risk group for malaria in the US (please circle the best answer):
    a. Blood transfusion recipients
    b. Native-born US citizens who seek travel medicine consultation prior to international travel
    c. Travelers to Western Europe and Australia
    d. Immigrants from malaria-endemic regions who return to their home countries to visit friends and relatives
2) How do you make a definitive diagnosis of malaria? (please circle the best answer)
    a. A single thin blood smear
    b. Repeated thick and thin blood smears
    c. Antigen and serology tests
    d. Blood cultures
3) For whom should you make a rapid presumptive diagnosis of malaria? (circle the best answer)
    a. A patient with cyclical fevers
    b. A returned traveler with a fever who appears well
    c. An ill patient who has recently returned from a malaria-endemic region
    d. Only in a returned traveler who was not taking malaria prophylaxis.
4) When should you initiate treatment for severe malaria? (please circle the best answer)
    a. Once you have a positive blood smear for malaria
    b. Once you have a positive blood smear for malaria and identified the species
    c. Presumptively, in any severely ill patient with a fever without a clear source
    d. Presumptively, in any severely ill patient who has traveled to a malaria-endemic region within the last year.
5) The only first-line drug for severe malaria available in the US is: (please circle the best answer)
    a. Quinine
    b. Artemisinin
    c. Quinidine
    d. Doxycycline
    e. Mefloquine
6) What is the major complication/toxicity of this first-line drug? (circle the single best answer)
    a. Tinnitus and hearing loss
    b. Cardiac toxicity with prolonged QT interval and arrhythmias
    c. Photo-sensitivity and GI upset
    d. Psychosis
    e. Anaphylactoid reaction
7) Name the two most common complications of severe malaria in adults: (circle two best answers)
    a. Hypoglycemia and thrombocytopenia
    b. ARDS and DIC
    c. Coma and severe metabolic acidosis
    d. Renal failure and ARDS
    e. Severe anemia and seizures
    f. Severe acidosis and liver failure
8) Name resources to help you manage severe malaria (please circle the best answer)
    a. CDC website and hotline
    b. Infectious disease consultants
    c. Pocket guides (such as Sanford), hospital pharmacists, & other prescribing guides
    d. All of the above