Medical-Crisis Checklists in the Emergency Department: A Simulation-Based Multi-Institutional Randomized Controlled Trial Appendix 1

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I. Checklist Design & Content

A variety of sources, including literature pertaining to Emergency and Abnormal Checklists in the aviation industry, were used to guide the design and content of the checklists assessed in the current study.[1-7] The checklists were developed through an iterative process involving specialists and residents in Emergency Medicine and senior nurses working in the emergency department (ED).

Display

The checklists were designed to be displayed on a wide screen and be visible to all team members involved in the management of a critical patient in the resuscitation room.

Interface

The checklists were stored on a tablet computer connected to the wide screen.

Layout

The backbone of each checklist consisted of a numbered list of potentially indicated interventions. The text of the backbone was limited to medical names (e.g. "Atropine?") and actions (e.g. "Endotracheal intubation?") to enhance readability.

Symbology

When a question mark featured after the intervention, it indicated that the intervention had specific indications and contraindications. When no question mark was present, it indicated that the intervention was indicated for all patients with the given diagnosis.

Each intervention displayed on the checklist was followed by a popover icon (a white plus sign within a red dot). This icon symbolized the presence of additional information.

Popover Windows

Pushing on the popover icon on the tablet computer's screen lead to the appearance of a popover window that covered only part of the checklist backbone. The popover window included specific information regarding the intervention, namely:

- indication(s)
- contraindication(s) and/or risk(s)
- name(s) and concentration(s) of the medication
- location of the medication
- dose or volume
- preparation
- route and rate of administration

Typography

A sans sérif font (Arial) and minimal text size of 30 points were used to enhance legibility. The default colours were black on a white background. The colour green was used to highlight the word "Indications", the colour red to highlight the words "Contraindications", "Risks" and special aspects of intervention delivery prone to mistakes, and the colour blue was used to indicate the location of the medication.

Navigation

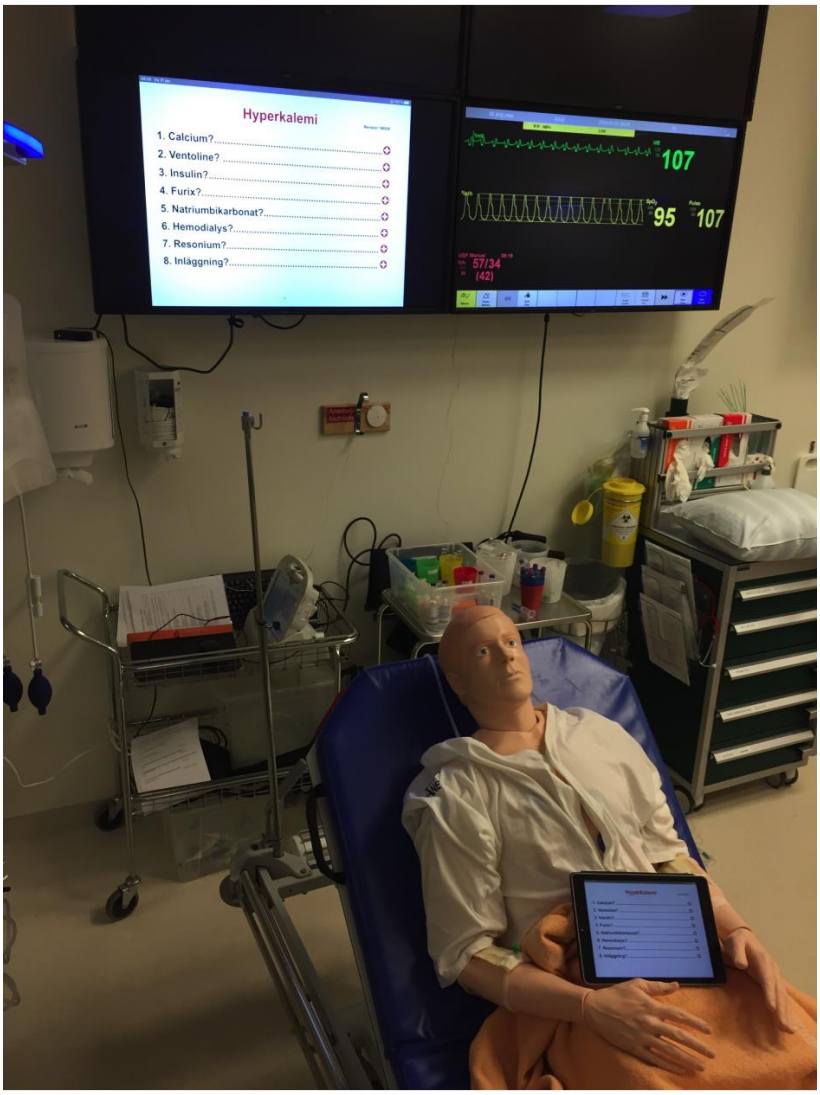
The backbone of the checklist for each medical crisis fitted on a single page. Popover windows were opened by pressing on the popover icon. The window was then closed by pressing on the screen outside the popover window. Within the context of the study, there

was no need to navigate between different pages, with the exception of scenario 4 (severe sepsis) where pressing on the word Antibiotics brought forth a separate screen with antibiotic guidelines.

Content
Current authoritative sources were used to obtain a list of potentially indicated interventions for each of the eight medical crises selected for the study. UpToDate® was one of the primary sources. Other sources included guidelines from the European Resuscitation Council and recommendations from the Swedish Poisoning Control Center. Based on these sources, four specialists in Emergency Medicine who work clinically in three of the four study sites determined through consensus whether to include these interventions in the checklists, and in which order to list the interventions.

Local Adaptation
The medication names used in the checklists' backbones were those most commonly used in local clinical practice, regardless of whether the name was generic or brand. Additional names were provided in the popover window. All medications featuring in the eight checklists were reviewed with an experienced nurse and physician in each ED before carrying out the study there. The purpose of this review was to ensure that the medications were available locally, that the medication names featuring in the checklist backbone were those most commonly used, and to fill in the locations of the medications. The nurses and physicians involved in this review process did not participate in the simulations.

Appendix 1 Figure 1: Checklist Display



Appendix 1 Figure 1 legend: The checklists were stored on a tablet computer and displayed on large screen for all team members to see throughout the simulation. This picture was taken at one of the study sites. A demonstration checklist (hyperkalemia) is on display.

II. Study Checklists

The following eight medical crises were selected for the study:

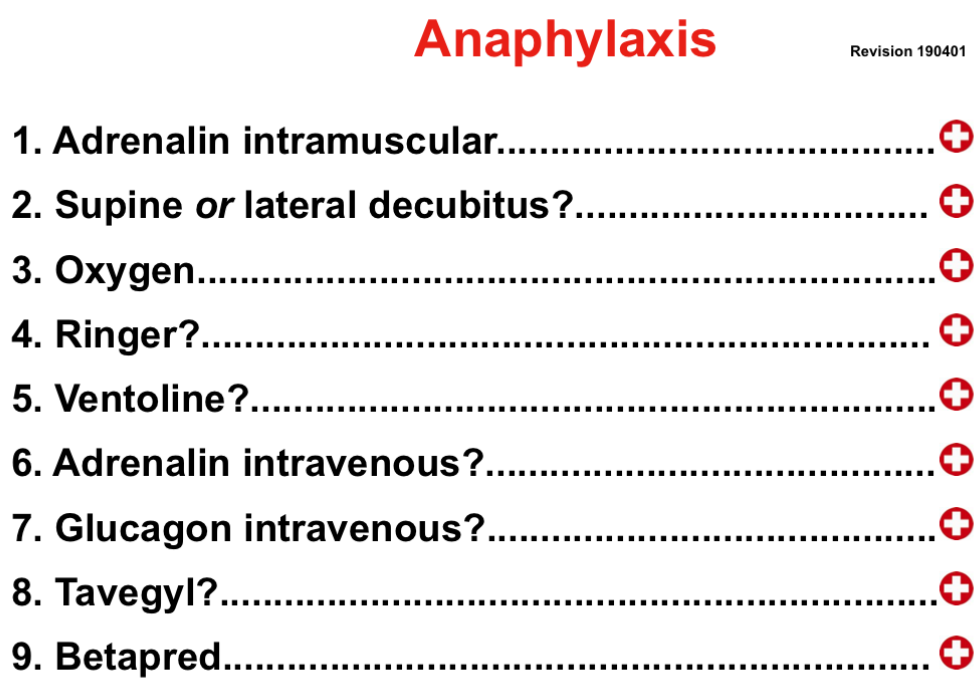
- Anaphylactic shock
- Life-threatening asthma exacerbation
- Hemorrhagic shock from upper gastrointestinal bleed
- Septic shock
- Poisoning from a calcium antagonist
- Poisoning from a tricyclic antidepressant
- Status epilepticus
- Increased intracranial pressure

The following sections provide:

- The backbones of each checklist; the medication names provided in the backbone are those commonly used in the ED where the study was conducted
- The content of the popover windows for each intervention
- The sources used to justify the content of the popover window; for some interventions, comments are provided

1. Anaphylaxis

Appendix 1 Figure 2: Anaphylaxis Checklist



1. Adrenalin intramuscular

Indication: all patients
Adrenalin 1 mg/ml (location) 0.5 ml
intramuscular anterolateral thigh
Can repeat every 5 min

Sources: [8 9]

2. Supine *or* lateral decubitus?

Indication: low blood pressure/feeling faint (prevents severe hypotension)
Contraindication: if the patient wants to remain upright due do shortness of breath
Supine
Lateral decubitus if nausea
Left lateral decubitus if advanced pregnancy

Sources: [8 9]

3. Oxygen

Indication: all patients
Oxygen ≥ 10 L/min via **mask with reservoir**

Sources: [8-10]

4. Ringer?

Indication: low blood pressure
Ringer (location) 1000 ml **IV bolus**

Sources: [8 9]

5. Ventoline?

Indication: bronchospasm/ronchi
Risk: hypokalemia
Ventoline (Salbutamol, Airomir) (location)
2 mg/ml 2.5 ml (1 ampule) **nebulised**
(can be given with patient in lateral decubitus)

Sources: [8 9]

6. Adrenalin intravenous?

Indication: severe symptoms despite adrenalin IM
Risk: arrhythmia (EKG monitoring)
Take a 10 ml syringe
Draw up 1 ml of **Adrenalin 0.1 mg/ml** (location)
Dilute with 9 ml NaCl
Give 5 ml of the solution (50 microg) **IV over 1 min**
Repeat after 3 min as needed

Sources: [8 9]

7. Glucagon intravenous?

Indication: severe symptoms unresponsive to adrenalin (e.g. use of **beta-blocker**)
Risk: vomiting
Glucagon 1 mg/ml (location)
Inject the fluid into the vial and mixed with the powder
Draw up the solution using a **separate syringe**
Inject the solution (1 ml) **IV over 1 min**
Repeat as needed

Sources: [8 9 11 12]

8. Tavegyl?

Indication: itch/hives
Tavegyl (Klemastin) (location)
1 mg/ml 2 ml **IV**

Sources: [8 9]

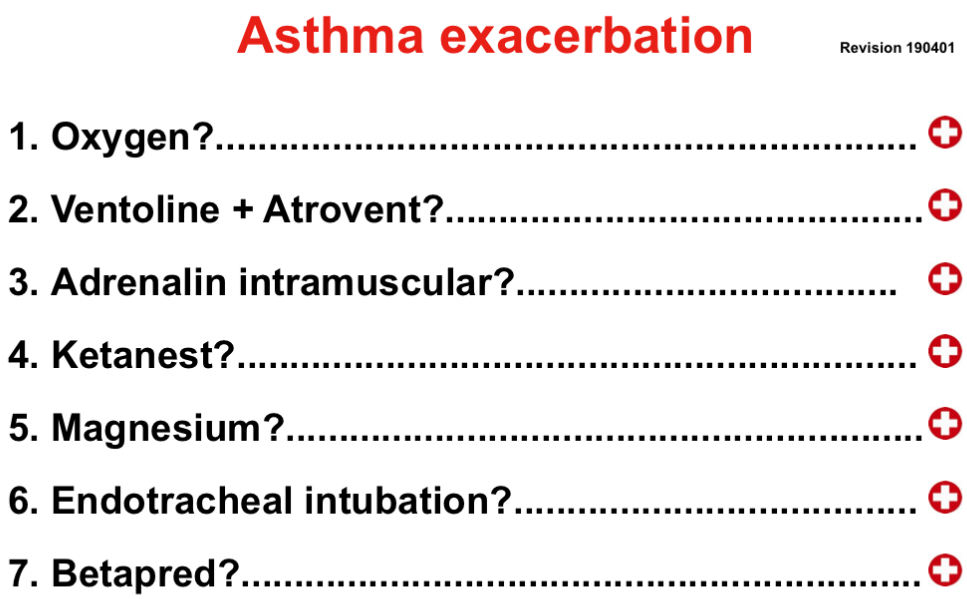
9. Betapred

Indication: all patients
Betapred 4 mg/ml (location) 2 ml **IV**

Sources: [8 9]

2. Asthma Exacerbation

Appendix 1 Figure 3: Asthma Exacerbation Checklist



1. Oxygen?

Indication: SpO2 < 93%
Oxygen via nasal prongs *or* oxygen mask
or nebulizer mask with **target SpO2 94-98%**
Sources: [9 13]

2. Ventoline + Atrovent?

Indication: alla
Risk: hypokalemia
Ventoline (Salbutamol, Airomir) 2 mg/ml (location)
2,5 ml (1 ampull)
+ Atrovent (Ipratropium) 0,25 mg/ml (location)
2 ml (1 ampull) **nebulized**
Repeat immediately if no improvement
Sources: [9 13 14]

3. Adrenalin intramuscular?

Indication: severe exacerbation + can't inhale Ventoline
Adrenalin 1 mg/ml (location)
0.5 ml **intramuscular** anterolateral thigh
Sources: [9 13 14]

Comment: recommending Adrenalin 0.5 mg IM as the default therapy for patients with acute severe asthma unable to use inhale bronchodilators can be justified according to the following arguments:
1-Asthma and anaphylaxis may be difficult to distinguish
2-Some patients with severe asthma may be dehydrated, and hence IM or IV is preferable as the default administration modality than SC
3-It is likely that the team can administer Adrenalin 1 mg/ml 0.5 mg IM more rapidly and confidently than Terbutaline 0.25 mg SC or Salbutamol 0.25 mg IV, since it is a well-established first-line treatment for anaphylaxis

4. Ketanest?

Indication: severe exacerbation + severe agitation which impairs treatment
Has PVK: **Ketanest (Esketamin) 5 mg/ml** (location) 10 ml **IV over 2 min**
No PVK: **Ketanest (Esketamin) 25 mg/ml** (location) 3 ml IM in each anterolateral thigh (total 6 ml)
Sources: [13-16]

5. Magnesium?

Indication: severe exacerbation unresponsive to above treatments
Risks: vomiting, hypotension
Magnesium (Addex) 1 mmol/ml (2.5 g/10 ml) (location) 8 ml in 100 ml NaCl **IV over 20 min**
Sources: [9 13 14]

6. Endotracheal intubation?

One or several of the following indicate life-threatening exacerbation:
- **SpO2 < 92%** *or* **PaO2 < 8**
- **pCO2 > 5.5 arterial** *or* **> 6.5 venous** *or* **rising**
- **Diminished breath sounds** on lung auscultation
- **Hypotension** *or* **arrhythmia**
- **Altered level of consciousness**

Call anesthesia *or* Call a Code
Sources: [9 13]

7. Betapred?

Indication: exacerbation that does not respond promptly to Ventoline
Betapred 4 mg/ml (location) 2 ml **IV**
Sources: [9 13 14]

3. Upper Gastrointestinal Bleeding

Appendix 1 Figure 4: Upper Gastrointestinal Bleed Checklist

1. Ringer?

Indication: blodtryck < 90 mm Hg
Ringer (location) 500 ml **IV bolus**
Sources: [17 18]

2. Blood tests

Indication: alla
BBT + Thrombocytes + INR + aPTT + Type and Cross-Match
If severe bleeding: + Fibrinogen
Sources: [17 19]
Comment: the following are included in BBT (bedside blood test): pH, pO2, pCO2, Na, K, Cl, Ca, glucose, Creatinine, Hb, lactate

3. Prevent hypothermia

Indication: all
Remove wet clothes
Cover with blanket
Source: [19]

4. Blood transfusion?

Indication: blood pressure < 90 mm Hg *or* Hb < 70

or Hb < 90 + [ongoing blood loss *or* ischemic heart disease]
0 negative blood (location) 1-2 SAG via Fluido
Source: [17]
Comment: Fluido is a device to warms fluids prior to intravenous administration

5. Confidex - Konakion - Praxbind?

Indication: severe bleeding in a patient taking Warfarin *or* NOAC
If Warfarin, Eliquis, Xarelto, Lixiana:
Ocplex *or* **Confidex** (location) 2000 E IV
If Warfarin: **Konakion** (location) 10 mg IV
If Pradaxa: **Praxbind** (location) 5 g IV over 5 min
Sources: [17 20 21]
Comment: Konakion is vitamin K1

6. Desmopressin?

Indication: severe bleeding in a patient taking Aspirin
Desmopressin (Octostim) 15 mikrog/ml (location)
1 ml (50 kg) - 2 ml (100 kg) diluted in 10 ml NaCl
IV over 10 min
Sources: [21 22]

7. Terlipressin?

Indication: liver cirrhosis + blood pressure < 100 mm Hg
Terlipressin (Glypressin) (location) 2 mg **IV**
Sources: [17 23 24]

8. Antibiotics?

Indication: liver cirrhosis + blood pressure < 100 mm Hg
Risk: allergy to antibiotic
Cefotaxim (location) 1 g **IV over 3 min**
Sources: [17 23]

9. Nexium

Indication: all
Nexium (Esomeprazol) (location) 80 mg **IV**
Sources: [17]

10. Cyklokapron?

Indication: severe bleeding
Cyklokapron (Tranexamic acid, Statraxen) 100 mg/ml (location) 10 ml **IV over 10 min**
Sources: [19 21 25 26]
Comment: there is broad consensus in the medical literature that Tranexamic acid is indicated in the setting of serious bleeding in general. There appear to be few risks associated with the medication in the absence of urogenital hemorrhage. One of the sources above suggests that Tranexamic acid has a synergic effect on hemostasis when given along with Desmopressin in the setting of bleeding in a patient taking ASA. In the specific setting of upper gastrointestinal bleeding, a Cochrane meta-analysis suggests decreased mortality associated with tranexamic acid, but the authors considered the studies to be insufficiently powered and

of poor quality. Several on-going trials are investigating the issue. Notwithstanding, in the setting of hemorrhagic chock, a fairly strong case can be made based on available sources to justify giving Tranexamic acid.

11. Calcium?

Ionised calcium < 1.0: Calcium Gluconate 10% (location)
10 ml **IV over 5 min**
Blood transfusion in liver disease: Calcium Gluconate 10%
10 ml **IV over 5 min for each SAG**

Sources: [19 27]

4. Sepsis

Appendix 1 Figure 5: Sepsis Checklist

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1. Oxygen?

SpO2 ≤ 90%: Oxygen 10 L/min via oxygen mask
SpO2 91-95%: Oxygen 3 L/min via nasal prongs

Sources: [28 29]

2. Ringer?

Indication: all
Ringer 500 ml (location) IV bolus
Repeat directly if remains hypotensive

Sources: [28 29]

3. Adrenalin intravenous?

Indication: SBT < 60 mm Hg
Risk: arrhythmia (monitor EKG)
Take a 10 ml syringe
Draw up 1 ml **Adrenalin 0.1 mg/ml** (location)
Dilute with 9 ml NaCl and mix
Give 2 ml (20 mikrog) **IV bolus**
Repeat after 3 min as needed

Sources: [29-31]

4. Cultures

Indication: all

Blood cultures (aerobic + anaerobic) x 2
Urine culture + urine dipstick
Consider cultures from **suspected infectious foci** (wound, nasopharynx); rapid strep-A test, urine antigen?
Sources: [28 29]

5. Foley Catheter?

Indication: low blood pressure *or* elevated lactate
Foley for urine output (+ obtain urine for culture)
Source: [29]

6. Antibiotics

Indication: give even if urine cannot be obtained for culture
Risk: allergy to antibiotic
See table (press on "**Antibiotics**")
Sources: [28 29]

7. Solu-Cortef?

Indication: known adrenal insufficiency *or* chronic corticosteroid treatment
Solu-Cortef (Hydrocortisone) (location) 100 mg **IV bolus**
Sources: [28 29]

8. Targeted investigations?

Indication: suspected infectious focus where procedure is required
Abscess, empyema, obstructive pyelonephritis, bowel perforation: X-ray *or* ultrasound
Necrotising fasciitis: surgery- *or* orthopedic consult
Sources: [28 29]

Antibiotics

Appendix 1 Figure 6: Antibiotics Checklist

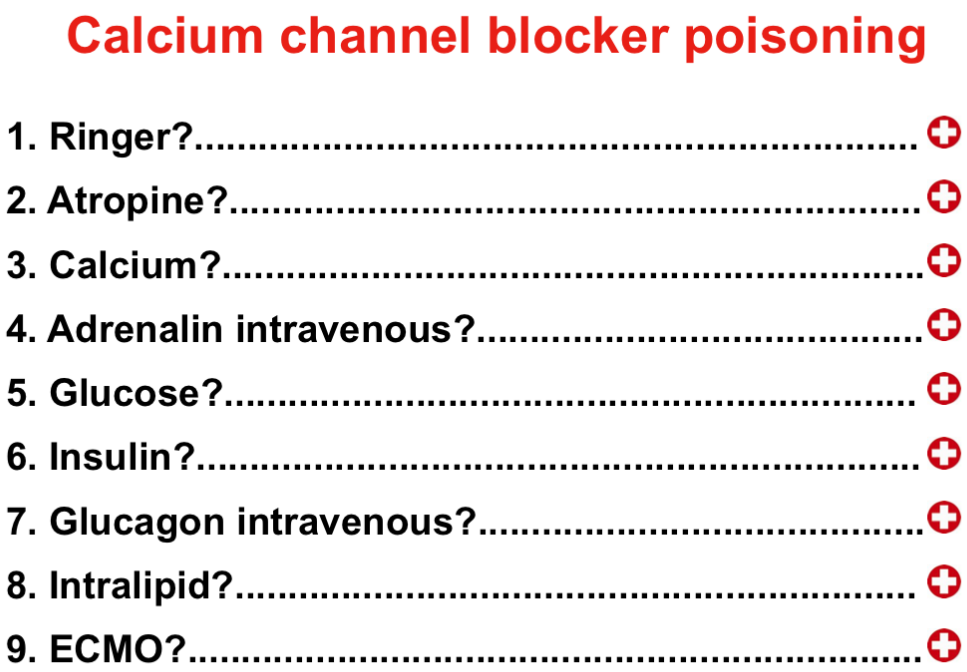
FOCUS	ANTIBIOTICS
Lung	• **Bensylpenicillin** 3g IV + **Levofloxacin** 750 mg IV *or* PO • If severe underlying lung disease: **Piperacillin/Tazobactam** 4g IV + **Levofloxacin** 750 mg IV *or* PO • If severe pc-allergy: **Clindamycin** 600 mg IV + **Levofloxacin** 750 mg IV *eller* PO
Abdomen	• **Piperacillin/Tazobactam** 4g IV • If septic shock: **Meropenem** 1g IV + **Tobramycin (Nebcina)** 5 mg/kg IV • If severe pc-allergy: **Meropenem** 1g IV
Urinary Tract	• **Cefotaxim** 2g IV • If septic shock: **Meropenem** 1g IV + **Tobramycin (Nebcina)** 5 mg/kg IV • If severe pc-allergy: **Meropenem** 1g IV
Joint & Bone	• **Cefotaxim** 2g IV • If septic shock: **Cefotaxim** 2g IV + **Tobramycin (Nebcina)** 5 mg/kg IV • If severe pc-allergy: **Meropenem** 1g IV
Fascia & Toxic Shock	• **Meropenem** 1g IV + **Clindamycin (Dalacin)** 600 mg IV • If septic shock: **Meropenem** 1g IV + **Clindamycin (Dalacin)** 600 mg IV + **Tobramycin (Nebcina)** 5 mg/kg IV
Unknown	• If sepsis: **Piperacillin/Tazobaktam** 4g IV • If septic shock: **Meropenem** 1g IV + **Tobramycin (Nebcina)** 5 mg/kg IV • If severe pc-allergy: **Meropenem** 1g IV
Neutro-penic	• **Meropenem** 1g IV • If septic shock: **Meropenem** 1 g IV + **Tobramycin (Nebcina)** 5 mg/kg IV

10

Source: Adapted from Strama Nationell. https://strama.se/behandlingsrekommendationer/app-strama-nationell/ cited 2019 June 1st
Comment: in the setting of toxic shock syndrome, the antibiotic regimen should include Clindamycin [29 32 33]

5. Calcium Channel Blocker Poisoning

Appendix 1 Figure 7: Calcium Channel Blocker Poisoning Checklist



6

1. Ringer?

Indication: low blood pressure
Ringer (location) 1000 ml **IV bolus**
Sources: [34-36]

2. Atropine?

Indication: bradycardia
Atropine 0.5 mg/ml (location) 2 ml (1 mg) **IV bolus**
Can repeat up to a max of 3 mg
Sources: [34 36]

3. Calcium?

Indication: low blood pressure
Calcium Gluconate 10% (location) 30 ml **IV over 5 min**
Sources: [9 34-36]

4. Adrenalin intravenous?

Indication: critical patient (severe hypotension *or* bradycardia)
Risk: arrhythmia (monitor EKG)
Take a 10 ml syringe
Draw up 1 ml **Adrenalin 0.1 mg/ml** (location)
Dilute with 9 ml NaCl and mix
Give 2 ml (20 mikrog) **IV bolus**

Repeat after 3 min as needed
Sources: [34-36]

5. Glucose?

Indication: critical patient (severe hypotension *or* bradycardia); given along with **6. Insulin**
Glucose 300 mg/ml (30%) (location) 50 ml **IV bolus**
Sources: [9 34-36]

6. Insulin?

Indication: critical patient (severe hypotension *or* bradycardia); given along with **5. Glucose**
Risk: hypokalemia
Humalog *or* Actrapid *or* Novorapid (location) 1 E/kg **IV bolus** (70 E for a 70 kg patient)
Sources: [9 34-36]

7. Glucagon intravenous?

Indication: critical patient (severe hypotension *or* bradycardia)
Risk: vomiting
Glucagon 1 mg/ml (location)
Inject the fluid into the vial and mixed with the powder
Draw up the solution using a **separate syringe**
Give 5 ml IV bolus (i.e. 5 packs)
Sources: [9 34-36]

8. Intralipid?

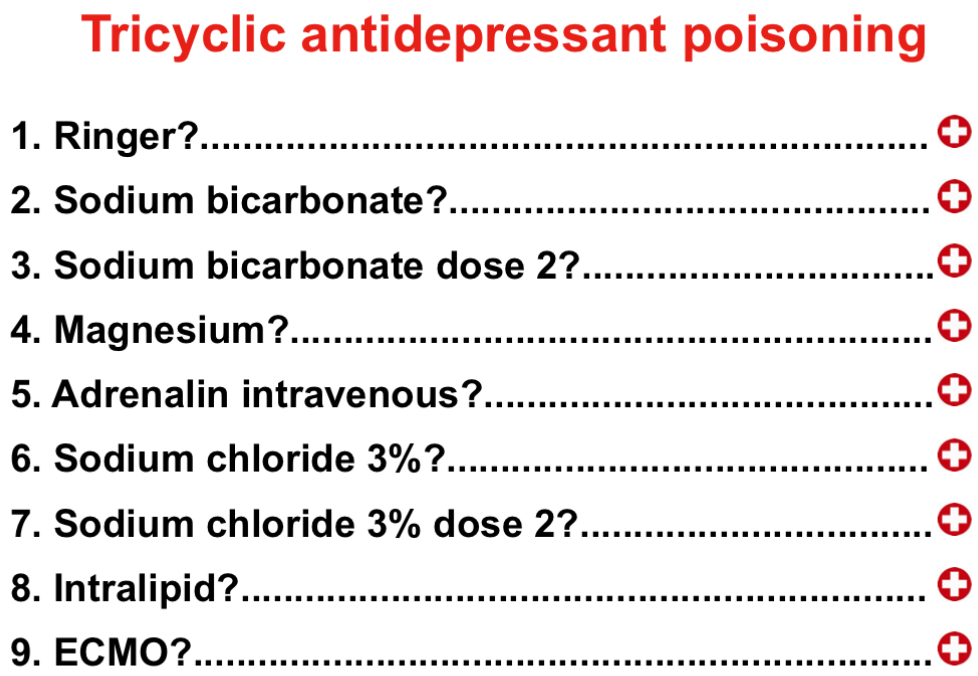
Indication: cardiac arrest *or* critically low blood pressure
Intralipid 200 mg/ml (location) 100 ml **IV over 1 min**
Repeat every 5th minute x 2
Sources: [34 35]

9. ECMO?

Indication: cardiac arrest *or* critically low blood pressure
Extracorporeal membrane oxygenation (ECMO) - contact thoracics #####
Sources: [9 34-36]

6. Tricyclic Antidepressant Poisoning

Appendix 1 Figure 8: Tricyclic Antidepressant Poisoning Checklist



7

1. Ringer?

Indication: low blood pressure
Ringer (location) 500 ml IV bolus

Sources: [37 38]

Comment: Isotonic saline contains 154 mmol/L of Na. Ringer's acetate contains 130 mmol/L of Na. It is dubious that there is a significant clinical effect for isotonic saline over Ringer's acetate. The point of this therapy is to expand intravascular volume, while the point of NaHCO3 therapy is to increase the Na gradient and improve myocyte function. Ringer's acetate is chosen here since it is the most commonly used crystalloid in our emergency departments.

2. Sodium bicarbonate?

Indication: wide QRS complex *or* low blood pressure *or* ventricular tachycardia
Sodium bicarbonate 50 mg/ml (location) 200 ml **IV bolus**

Sources: [37-39].

3. Sodium bicarbonate dose 2?

Indication: remaining wide QRS complex *or* low blood pressure *or* ventricular tachycardia
Sodium bicarbonate 50 mg/ml (location) 200 ml **IV bolus**

Source: [37 39].

4. Magnesium?

Indication: ventricular tachycardia despite Sodium bicarbonate bolus x 2

Magnesium (Addex) 1 mmol/ml (2.5 g/10 ml) (location)
10 ml **IV over 2 min**
Sources: [37 38]

5. Adrenalin intravenous?

Indication: remaining low blood pressure despite Sodium bicarbonate bolus x 2
Risk: arrhythmia (monitor EKG)
Take a 10 ml syringe
Draw up 1 ml **Adrenalin 0.1 mg/ml** (location)
Dilute with 9 ml NaCl and mix
Give 2 ml (20 mikrog) **IV bolus**
Repeat after 3 min as needed
Sources: [30 31 37 38]

6. Sodium chloride 3%?

Indication: remaining low blood pressure despite above treatment
Fetch **Sodium chloride 9 mg/ml (isotonic NaCl)** (location) 100 ml
Add **Addex-Sodium chloride 4 mmol/ml** (location) 10 ml
Give the whole solution (110 ml) as **IV bolus**
Source: [37 39]

7. Sodium chloride 3% dose 2?

Indication: remaining low blood pressure 10 min after Sodium chloride 3% bolus
Fetch **Sodium chloride 9 mg/ml (isotonic NaCl)** (location) 100 ml
Add **Addex-Sodium chloride 4 mmol/ml** (location) 10 ml
Give the whole solution (110 ml) as **IV bolus**
Source: [37 39]

8. Intralipid?

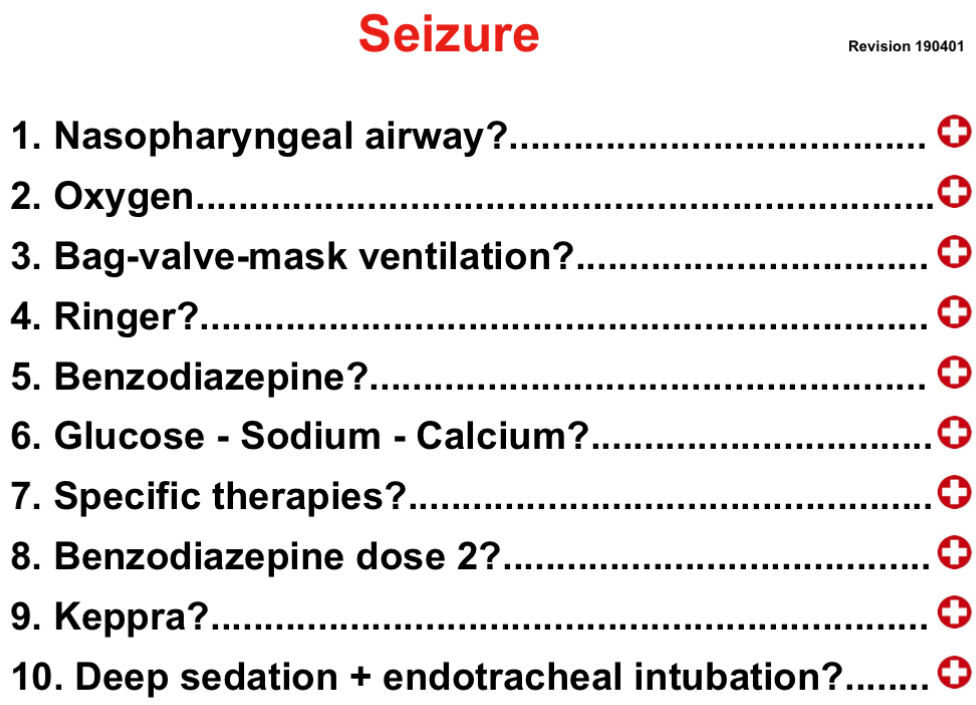
Indication: cardiac arrest *or* critically low blood pressure
Intralipid 200 mg/ml (location) 100 ml **IV over 1 min**
Repeat every 5th minute x 2
Source: [37 38]

9. ECMO?

Indication: cardiac arrest *or* critically low blood pressure
Extracorporeal membrane oxygenation (ECMO) - contact thoracics #####
Source: [38 40]

7. Seizure

Appendix 1 Figure 9: Seizure Checklist



1. Nasopharyngeal airway?

Indication: obstructive airway sounds
Risk: high-energy facial trauma (skull base fracture)
Nasal pharyngeal airway

Sources: [41 42].

2. Oxygen

Indication: all
≥ 10 L/min via oxygen mask

Sources: [41 43]

3. Bag-valve-mask ventilation?

Indication: low respiratory rate (< 10/min), reduced chest excursions
Bag-valve-mask connected to oxygen 12 breaths/min

Sources: [41 44]

4. Ringer?

Indication: blood pressure < 120 mm Hg
Ringer (location) 500 ml **IV bolus**

Sources: [41 44 45]

5. Benzodiazepine?

Indication: ≥ 5 minutes of continuous *or* intermittent seizure

Stesolid (Diazepam) (location) 10 mg **IV bolus**
or **Midazolam** (location) 10 mg **IM**

Sources: [41 46 47]

6. Glucose - Sodium - Calcium?

Hypoglycemia:
Glucose 300 mg/ml (30%) (location) 30 ml **IV bolus**

Hyponatremia:
Fetch **Sodium chloride 9 mg/ml (isotonic)** (location) 250 ml
Add **Addex-Sodium chloride 4 mmol/ml** 20 ml
Give the whole solution (270 ml) as **IV bolus**

Hypocalcemia:
Calcium gluconate 10% (location) 10 ml **IV over 5 min**

Source for hyponatremia: [48 49]

7. Specific therapies?

Meningoencephalitis:
Betapred (location) 10 mg + **Cefotaxim** (location) 3 g
+ **Doktacillin** (location) 3 g + **Acyclovir** (location) 10 mg/kg **IV**

Eclampsia:
Magnesium (Addex) 1 mmol/ml (2.5 g/10 ml) (location)
20 ml **IV over 5 min**

Intoxication *and* wide QRS-complex:
Sodium bicarbonate 50 mg/ml (location) 200 ml **IV bolus**

Comment: these situations and specific therapies were included for the sake of completeness but not relevant to the simulation used in the study.

8. Benzodiazepine dose 2?

Indication: continuous *or* intermittent seizure
despite Stesolid (Diazepam) *or* Lorazepam IV
Stesolid (Diazepam) (location) 10 mg **IV bolus**

Sources: [41 46 47].

9. Keppra?

Indication: ≥ 5 minutes of continuous *or* intermittent seizure
regardless of response to treatment with Stesolid (Diazepam) *or* Midazolam
Keppra (Levetiracetam, Matever) 100 mg/ml (location)
60 mg/kg (max 6000 mg) **IV over 10 min**

Sources: [41 46 47].

Comment: guidelines available throughout the study period recommended Levetiracetam, Fosphenytoin or Valproic acid as second line therapy for status epilepticus, and stated that there was no convincing evidence that one medication was superior to the others. Fosphenytoin has a number of cardiovascular side-effects which Levetiracetam lacks. All emergency departments involved in the study had access to Levetiracetam. To improve readability, the checklist featured only Levetiracetam as second line therapy.

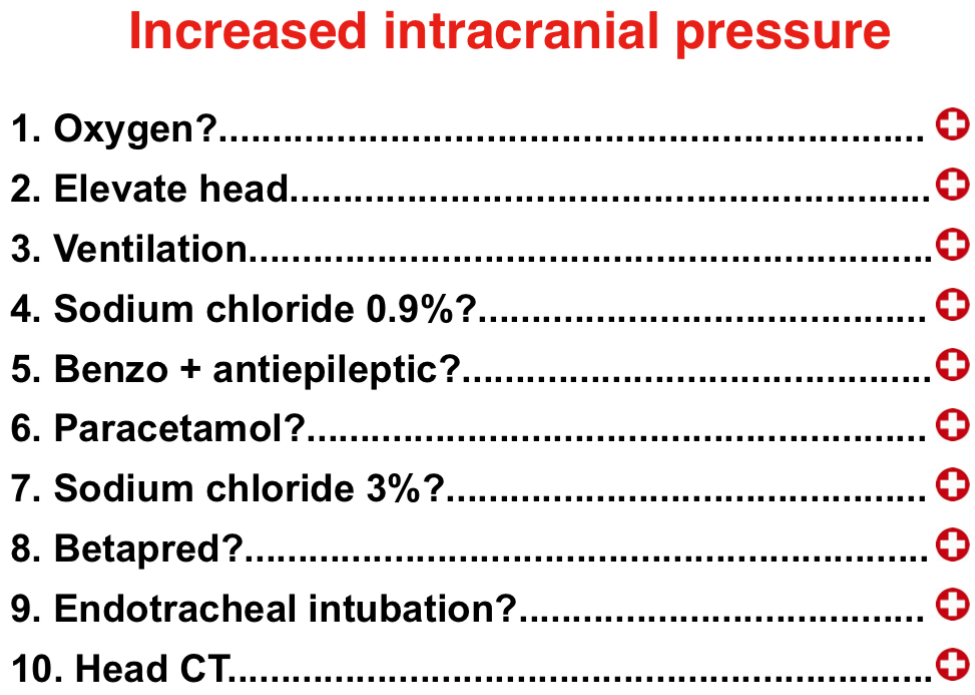
10. Deep sedation + endotracheal intubation?

Indication: continuous *or* intermittent seizures persist despite above therapy
Summon anaesthesia for deep sedation and endotracheal intubation

Source: [41]

8. Increased Intracranial Pressure

Appendix 1 Figure 10: Increased Intracranial Pressure Checklist



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1. Oxygen?

Indication: SpO2 < 95%
Oxygen 10 L/min via oxygen mask
Source: [50]

2. Elevate head

Indication: all
Elevate the head of the bed by 30° *or* **tip the gurney (reverse Trendelenburg)** in order to increase venous return from the brain
Sources: [50 51]

3. Ventilation

Indication: all
Follow endtidal pCO2 (EtCO2)
Ventilate with **bag-valve-mask** *or* **via endotracheal tube** as needed
Aim for **EtCO2 5 kPa**
If unconscious + fixed dilated pupil (imminent coning): aim for **EtCO2 3.5 kPa**
Sources: [50 52 53]

4. Sodium chloride 0.9%?

Indication: blood pressure < 110 mm Hg
Sodium chloride 9 mg/ml (isotonic) (location) 500 ml IV bolus
Sources: [50 53 54]

5. Benzo + antiepileptic?

Indication: suspected seizure
Treat seizures aggressively since they increase brain metabolism
See checklist Seizure

Source: [50]

6. Paracetamol?

Indication: temperature > 37.7°C
Contraindication: allergy to paracetamol
Paracetamol 10 mg/ml (location) 100 ml IV *and/or* **physical measures**
Target normal body temperature

Sources: [50 52]

7. Sodium chloride 3%?

Indication: unconscious + fixed dilated pupil (**imminent coning**)
Fetch **Sodium chloride 9 mg/ml (isotonic)** (location) 250 ml
Add **Addex-Sodium chloride 4 mmol/ml** (location) 20 ml
Give the whole solution (270 ml) as **IV bolus**

Sources: [50 52 54-56]

8. Betapred?

Indication: known brain tumor *or* CNS-infection
Contraindication: traumatic brain injury, stroke
Betapred 4 mg/ml (location) 4 ml **IV**

Sources: [50 52 54]

9. Endotracheal intubation?

Indication: unconscious *or* severely reduced level of consciousness
Risk: drop in blood pressure impairs brain perfusion
Summon anaesthesia

Sources: [56]

10. Head CT

Indication: all
Head CT without contrast

Source: [54]

III. Scenarios & Emergency Interventions

Eight scenarios, one for each of the medical crises, were written based on real patients that had presented to the Emergency Department of _____. Introductory material was provided to the teams according to the SBAR format (Situation Background Assessment Recommendation) [57]. Real EKGs and blood gas results were provided to the teams during the simulations. During the study, blood gas values were provided in kPa, creatinine values in μmol/L, glucose in mmol/L and lactate in mmol/L. Values in other units are provided below using the following conversions:

- pO2 in mm Hg = pO2 in kPa x 7.5
- pCO2 in mm Hg = pCO2 kPa x 7.5
- Creatinine in mg/dl = Creatinine in μmol/L : 88.89
- Glucose in mg/dl = Glucose in mmol/L x 18
- Lactate in mg/dl = Lactate in mmol/L x 9

Emergency Intervention Criteria

For each scenario, seven to ten emergency interventions were identified a priori based on time-to-effect of the intervention and risk for patient deterioration if the intervention is not performed during the 30-minute time-frame of the management in the resuscitation room of a critically ill patient not responding to initial therapy. Determining which interventions were emergency ones was based on the authoritative sources used to generate the checklists and consensus from the specialists in emergency medicine working in the Emergency Departments where the study took place.

While calling for help is to be encouraged in the setting of a medical crisis, the act of calling for help was not considered an emergency intervention in the context of this study, since calling for help per se does not benefit the patient–rather, it is the administration of a medication or the performance of a procedure that is clinically beneficial.

Not all interventions featuring in the checklists were emergency interventions. For example, the administration of corticosteroids for anaphylaxis and for asthma exacerbation were not considered emergency interventions, since the effect of corticosteroids takes several hours to develop. The checklists were designed to be generic for the condition, and not all interventions featuring in the checklist were indicated in the context of the scenario. For example, the checklist for upper gastrointestinal hemorrhage featured interventions to reverse anticoagulants, but in the scenario, the patient did not take anticoagulants.

The administration of alternative treatments to those featuring in the checklist was acceptable as long as the treatment was considered equivalent and the dose adequate. For example, the checklist for seizure features administering Levetiracetam. The administration of Valproic acid in a reasonable dose was considered equivalent. The checklist recommended adding 10 ml of NaCl 4 mmol/ml to 100 ml of 0.9% NaCl or 20 ml of NaCl 4 mmol/ml to 250 ml of 0.9% NaCl to yield a solution of roughly 3% NaCl. Adding 40 ml of NaCl 4 mmol/ml to 500 ml of 0.9% NaCl was considered equivalent.

Based on the references used to derive the checklists, the study investigators decided a priori that given a medication dose lower than the one recommended by the checklist was not considered sufficient for the measure to be considered to have been performed, unless repeated doses were administered and the summative dose reached or exceeded the dose recommended by the checklist. For example, the checklist for seizure recommended giving 10 mg of Diazepam IV as first line antiepileptic treatment. Administering 5 mg of Diazepam

IV was not considered sufficient, but administering a second dose of 5 mg of Diazepam IV subsequently was considered equivalent to administering 10 mg of Diazepam.

The study investigators decided a priori that administering up to twice the medication dose recommended by the checklist was considered acceptable, but that exceeding this amount was not. For example, the checklist recommended giving 50 micrograms of adrenalin intravenously over 1 minute to a patient with anaphylactic chock who has not responded to intramuscular adrenalin and a bolus of crystalloid fluid. Giving 100 micrograms of adrenalin intravenously was considered equivalent, but giving 300 micrograms directly was considered dangerous and not equivalent.

1. Anaphylaxis

Manikin	**Running the Scenario**
• Reclining at a 45° angle • No oxygen mask • No PVC • Blanket covering the manikin	• If asked how he feels, the patient responds that he is "dizzy and nauseous." • The patient prefers to lie flat or sideways despite having trouble breathing. • Vital signs do not improve despite treatment

Introduction

S	A 50-year-old man has just presented to the emergency department after being stung by a wasp 5 minutes ago.
B	The patient has previously had a heart attack and is taking Aspirin and Metoprolol. He is also severely allergic to wasps.
A	The patient's arm was stung by a wasp 5 minutes ago outside the emergency department and the patient came here immediately.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	**Wheezing on expiration**
Oral Cavity	**Swollen tongue**

Breathing

SpO2%	**90% on room air**
Respiratory Rate	**40 breaths/min**
Lung Auscultation	**Bilateral wheezing on expiration**

Circulation

Blood Pressure	**60/30 mm Hg**
Heart Rate	**140 beats/min**
Monitor EKG	Narrow QRS-complexes, regular rhythm

Disability

Consciousness	**Barely responds to voice, drowsy**
Eyes	Pupils 4 mm
Extremities	Moves all 4 extremities spontaneously

Exposure

Front	**Pale, clammy**
Back	**Pale, clammy**
Temperature	37.2°C

Adjuncts

Blood Tests	Provided if requested
EKG	"EKG shows a sinus tachycardia"
Ultrasound	"No intrapleural or intraabdominal free fluid. Empty IVC"

Bedside Blood Tests

Blood Gas Values				
pH	7.28			
pCO_2	6.0	kPa	45	mm Hg
pO_2	4.03	kPa	30	mm Hg
Electrolyte Values				
Na^+	143	mmol/L		
K^+	4.8	mmol/L		
Creatinine	108	µmol/L	1.21	mg/dl
Ca^{2+}	1.23	mmol/L		
Cl^-	107	mmol/L		
Metabolite Values				
Glucose	8.8	mmol/L	158	mg/dl
Lactate	4.7	mmol/L	42.3	mg/dl
Oximetry Values				
Hb	137	g/L		
sO_2	70.6	%		
Other				
Base(Ecf)c	-5.1	mmol/L		
$HCO3^-$(P,st)c	20.3	mmol/L		

Emergency Interventions

1-Adrenalin 0.3 - 0.5 mg IM	5-Salbutamol 5 mg nebulised
2-Supine	6-Adrenalin 50 microg IV
3-Oxygen ≥ 10 L/min via reservoir mask	7-Glucagon 1 mg IV
4-Crystalloid 1000 ml IV bolus	

Comments

- Antihistamine administration was not considered an emergency intervention, since it does not impact on hypoxia/hypotension.
- Corticosteroid administration was not considered an emergency intervention, since several hours are require before corticosteroids have an effect.

2. Asthma Exacerbation

Manikin	**Running the Scenario**
• Reclining at a 45° angle • Nebuliser mask • Two PVCs • Blanket covering the manikin	• Saturation drops steadily during the scenario, from 93% initially to 85% at a rate of 1% drop/min. • Patient gets severely agitated 6 min into the scenario, takes off oxygen mask

Introduction

S	A 52-year-old man with shortness of breath will be arriving by ambulance in 1 minute.
B	The patient suffers from asthma and anxiety. He takes Oxis (Formoterol), Bricanyl (Terbutaline), Betapred as needed and Oxascand as needed.
A	He became short of breath 2 hours ago. He reports that it feels like the asthma attacks he has previously had, though worse this time. Ambulance personnel have been treating him for the last 15 minutes with 5 mg of Ventolin nebulized and have placed two PVCs.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	**Wheezing on expiration**
Oral Cavity	Unremarkable

Breathing

SpO2%	**93% initially, drops 1%/min despite supplementary oxygen**
Respiratory Rate	**35 breaths/min**
Lung Auscultation	**Bilateral wheezing on expiration, rather silent breath sounds**

Circulation

Blood Pressure	**190/110 mm Hg**
Heart Rate	**130 beats/min**
Monitor EKG	Narrow QRS-complexes, regular rhythm

Disability

Consciousness	Awake and alert, looks anxious, having trouble talking **Becomes severely agitated at +6 min and removes mask** **Becomes docile if receives Ketamin / Ketanest**
Eyes	Pupils 4 mm
Extremities	Moves all 4 extremities spontaneously

Exposure

Front	**Pale, clammy**
Back	**Pale, clammy**
Temperature	37.1°C

Adjuncts

Blood Tests	Provided if requested
EKG	"EKG shows a sinus tachycardia"
Ultrasound	"Bilateral lung-sliding, no pleural fluid, no B-lines, normal right ventricle, normal IVC"

Bedside Blood Tests

Blood Gas Values				
pH	7.17			
pCO_2	9.34	kPa	70	mm Hg
pO_2	13.9	kPa	104	mm Hg
Electrolyte Values				
Na^+	141	mmol/L		
K^+	4.6	mmol/L		
Creatinine	82	µmol/L	0.92	mg/dl
Ca^{2+}	1.25	mmol/L		
Cl^-	106	mmol/L		
Metabolite Values				
Glucose	12.0	mmol/L	216	mg/dl
Lactate	2.5	mmol/L	22.5	mg/dl
Oximetry Values				
Hb	170	g/L		
sO_2	95.6	%		
Other				
Base(Ecf)c	-2.7	mmol/L		
$HCO3^-$(P,st)c	19.6	mmol/L		

Emergency Interventions

1-Oxygen	5-Ketanest 5 mg/ml 10 ml IV over 2 min
2-Ventoline 5 mg (dose #2)	6-Magnesium 8 mmol IV over 20 min
3-Atrovent 0.5 mg (dose #1)	7-Summon anesthesia for endotracheal intubation
4-Adrenalin 0.5 mg IM	

Comments

- Intervention 4: alternatives to Adrenalin 0.5 mg IM considered to be equivalent:
  - Terbutaline (Bricanyl) 0.25 mg SC
  - Terbutaline (Bricanyl) 0.25 mg IV
  - Salbutamol 0.25 mg IV
- Intervention 5: alternative to Ketanest 5 mg/ml 10 ml IV considered to be equivalent:
  - Ketamine 10 mg/ml 10 ml IV
  - Ketanest 25 m/ml 6 ml IM
  - Ketamine 50 mg/ml 6 ml IM
- Corticosteroid administration was not considered an emergency intervention, since several hours are require before corticosteroids have an effect.

3. Upper Gastrointestinal Bleeding

Manikin	**Running the Scenario**
• Supine • Oxygen mask • Two PVCs • Blanket covering the manikin	• The patient reports feeling faint • Blood pressure increases from 70/40 to 90/60 if the patient receives intravenous fluids (crystalloids or blood)

Introduction

S	A 67-year-old man is brought to the emergency room because of hematemesis.
B	The patient lives alone. He takes Aspirin because of a heart attack 10 years ago. He suffers from chronic alcohol abuse and has liver cirrhosis.
A	Throughout the night, he has vomited a mixture of fresh blood and coffee grounds. He was found by home care and the ambulance personnel have placed 2 PVCs.
R	"All yours" (remove the blanket, leave it at the foot of the bed)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	Normal airway sounds
Oral Cavity	**Dried black coating on the tongue**

Breathing

SpO2%	97% while receiving 5 L/min oxygen via mask
Respiratory Rate	35 breaths/min
Lung Auscultation	Normal breath sounds

Circulation

Blood Pressure	**70/40 mm Hg**
Heart Rate	**130 beats/min**
Monitor EKG	Narrow QRS-complexes, regular rhythm

Disability

Consciousness	Alert
Eyes	Pupils 3 mm, **scleral icterus**
Extremities	Moves all 4 extremities spontaneously

Exposure

Front	**Pale, slightly yellow**, clammy, **swollen abdomen (suspected ascites),** no findings suggestive of peritonitis
Back	**Black foul-smelling faeces**
Temperature	36.0°C

Adjuncts

Blood Tests	Provided if requested
12-lead EKG	"EKG looks unchanged compared with previous EKG"
Ultrasound	No free fluid, empty IVC

Bedside Blood Tests

Blood Gas Values				
pH	7.41			
pCO_2	4.79	kPa	36	mm Hg
pO_2	2.03	kPa	21	mm Hg
Electrolyte Values				
Na^+	143	mmol/L		
K^+	4.8	mmol/L		
Creatinine	118	µmol/L	1.33	mg/dl
Ca^{2+}	1.16	mmol/L		
Cl^-	109	mmol/L		
Metabolite Values				
Glucose	8.8	mmol/L	158	mg/dl
Lactate	7.7	mmol/L	69.3	mg/dl
Oximetry Values				
Hb	37	g/L		
sO_2	10.6	%		
Other				
Base(Ecf)c	-1.8	mmol/L		
$HCO3^-$(P,st)c	22.3	mmol/L		

Emergency Interventions

1-Ringer 500 ml IV bolus	6-Terlipressin 2 mg IV
2-Blood tests including Fibrinogen	7-Cefotaxim 1 g IV
3-Blanket	8-Nexium 80 mg IV
4-O negative blood x 2 units	9-Cyklokapron 1 g IV over 10 min
5-Octostim 15 mikrog/ml 1 ml over 10 min	10-Calcium gluconate 10% 10-20 ml IV

Comments

- Intervention 2: blood tests are included as an emergency intervention since blood typing should be carried out prior to blood transfusion with O negative blood

4. Sepsis

Manikin	**Running the Scenario**
• Supine • No mask or nasal prongs • Two PVCs • Blanket covering the manikin	• Vital signs remain unchanged despite treatment

Introduction

S	A 42-year-old woman with a fever will be arriving in the emergency room in 1 minute via ambulance.
B	The patient underwent a sectoral resection of the right breast six weeks ago because an unclear tumor was detected; the pathology showed no malignancy. She is otherwise healthy.
A	For the past three days, the patient has had high fever and dry cough. During the last day, she has developed increasing pain in the right axilla and abdomen. Today, she became confused, and her husband called for an ambulance.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	Normal airway sounds
Oval Cavity	Unremarkable

Breathing

SpO2%	**92% on room air**
Respiratory Rate	**32 breaths/min**
Lung Auscultation	Normal breath sounds

Circulation

Blood Pressure	**55/30 mm Hg**
Heart Rate	**145 beats/min**
Monitor EKG	Narrow QRS-complexes, regular rhythm

Disability

Consciousness	Drowsy
Eyes	Pupils 3 mm, react to light
Extremities	Moves all 4 extremities spontaneously

Exposure

Front	**Salmon-colored / sunburn-like rash over the chest** **No petechiae. Right axilla: significantly warm, red, somewhat swollen**
Back	Normal skin
Temperature	40°C

Adjuncts

Blood Tests	Provided if requested
EKG	"EKG shows a sinus tachycardia"
Ultrasound	"Hyperkinetic heart, no pericardial fluid, empty IVC. No intraabdominal free fluid, **suspected fluid collection in the chest wall of the right axilla.** No free fluid in the pleural space, no lung consolidation."

Bedside Blood Tests

Blood Gas Values				
pH	7.18			
pCO_2	5.44	kPa	41	mm Hg
pO_2	2.91	kPa	22	mm Hg
Electrolyte Values				
Na^+	135	mmol/L		
K^+	4.0	mmol/L		
Creatinine	564	µmol/L	6.34	mg/dl
Ca^{2+}	1.06	mmol/L		
Cl^-	101	mmol/L		
Metabolite Values				
Glucose	6.6	mmol/L	119	mg/dl
Lactate	11.4	mmol/L	102.6	mg/dl
Oximetry Values				
Hb	141	g/L		
sO_2	26.0	%		
Other				
Base(Ecf)c	-12.2	mmol/L		
$HCO3^-$(P,st)c	13.3	mmol/L		

Emergency Interventions

1-Oxygen 3 L/min via nasal prongs/mask	5-Bladder catheter
2-Ringer 500 ml IV bolus, repeat as needed	6-Antibiotics, including Clindamycin
3-Adrenalin 20 microg IV bolus	7-X-ray/ultrasound ("abscess in the axilla?")
4-Blood cultures x 2 and urine culture	or surgical consult

Comments

- Intervention 4: both the words "blood culture" AND "urine culture" need to be mentioned
- Intervention 6: Clindamycin OCH another antibiotic which is either broad-spectrum or directed against Staphylococcus need to be administered

5. Calcium Channel Blocker Poisoning

Manikin	**Running the Scenario**
• Supine • Nasopharyngeal airway + oxygen mask with reservoir • Two PVCs, 1 liter Ringer's acetate connected to one PVC without surrounding blood pressure cuff • Blanket covering the manikin	• The vital signs remain unchanged throughout the scenario despite therapy

Introduction

S	A 45-year-old woman has been found with decreased level of consciousness in her apartment
B	The patient has high blood pressure and is on Cardizem Retard. She also suffers from depression.
A	The patient was found by her daughter. The patient had written a suicide note. 30 tablets of 180 mg Cardizem Retard are missing. It is unclear when the patient took the tablets. The ambulance personnel have placed two PVCs, nasopharyngeal airway, and the patient is receiving 10 L/min of oxygen via mask. The personnel state that they have not been able to palpate the radial pulse. They connected 1 L of Ringer just before arrival in the ED.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	Normal airway sounds, nasopharyngeal airway in place
Oral Cavity	Unremarkable

Breathing

SpO2%	96% while the patient is receiving 10 L/min O2 via mask
Respiratory Rate	20 breaths/min
Lung Auscultation	Normal breath sounds

Circulation

Blood Pressure	**70/50 mm Hg**
Heart Rate	**31 beats/min**
Monitor EKG	**Wide QRS-complexes**, regular rhythm

Disability

Consciousness	**Drowsy**
Eyes	Pupils 3 mm
Extremities	Moves all 4 extremities spontaneously

Exposure

Front	Normal skin
Back	Normal skin
Temperature	36.8°C

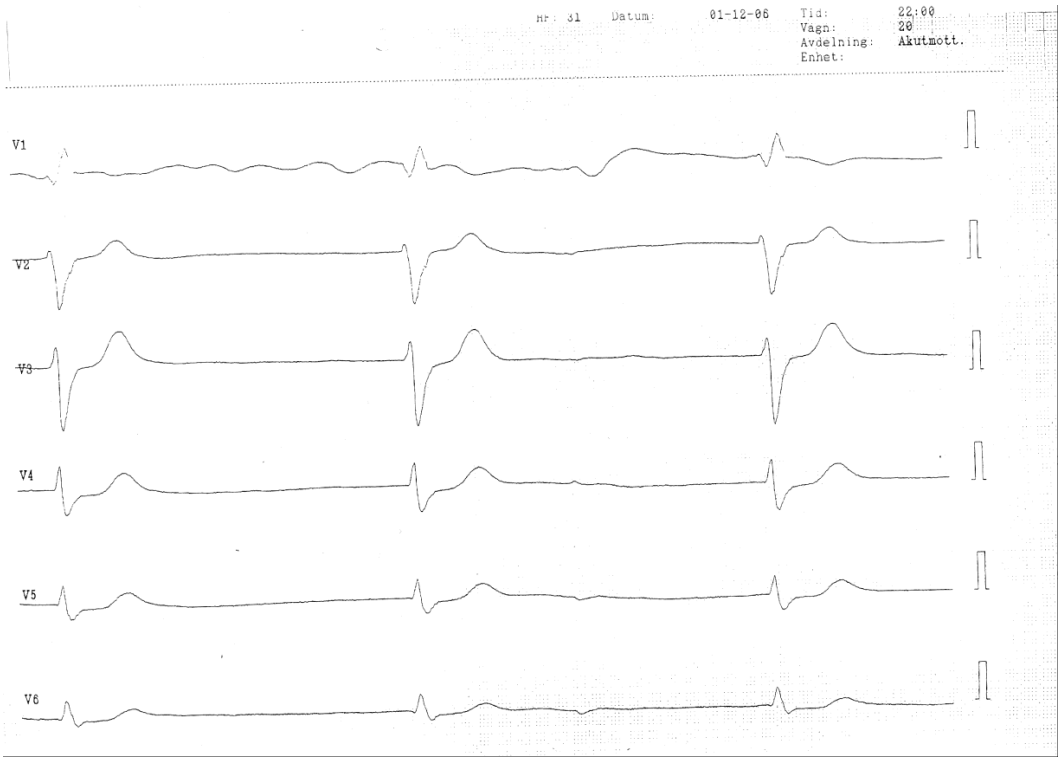
Adjuncts

Blood Tests	Provided if requested
EKGs	EKG #1a and EKG #1b are provided simultaneously if EKG is requested
Ultrasound	"No pericardial fluid. Poor contractility. Large IVC. No free fluid."

Bedside Blood Tests

Blood Gas Values				
pH	7.2			
pCO_2	6.79	kPa	51	mm Hg
pO_2	4.03	kPa	30	mm Hg
Electrolyte Values				
Na^+	141	mmol/L		
K^+	4.8	mmol/L		
Creatinine	104	µmol/L	1.17	mg/dl
Ca^{2+}	1.26	mmol/L		
Cl^-	107	mmol/L		
Metabolite Values				
Glucose	8.8	mmol/L	158	mg/dl
Lactate	6.2	mmol/L	55.8	mg/dl
Oximetry Values				
Hb	119	g/L		
sO_2	69.6	%		
Other				
Base(Ecf)c	-7.2	mmol/L		
$HCO3^-$(P,st)c	17.6	mmol/L		

Appendix 1 Figure 11: Calcium Channel Blocker Poisoning EKG #1a



Appendix 1 Figure 12: Calcium Channel Blocker Poisoning EKG #1b

Emergency Interventions

1-Ringer's acetate bolus	6-Humalog *or* Actrapid *or* Novorapid 70 E IV bolus
2-Atropine ≥ 1 mg IV bolus	7-Glucagon ≥ 1 mg IV bolus
3-Calcium gluconate 10% 30 ml IV	8-Intralipid 100 ml IV
4-Adrenalin 20 microg IV bolus	9-ECMO
5-Glucose 300 mg/ml 50 ml IV bolus	

Comments

- Intervention 8: since intralipid is not available at one of the four sites, the maximum number of potential emergency interventions with eight when the scenario was simulated there.
- Intervention 9: ECMO stands for extracorporeal membrane oxygenation

6. Tricyclic Antidepressant Poisoning

Manikin	**Running the Scenario**
• Supine • Nasopharyngeal airway + oxygen mask with reservoir • Two PVCs • Blanket covering the manikin	• Three minutes into the scenario, the patient develops ventricular tachycardia, which persists until the patient receives sodium bicarbonate dose #2 and magnesium IV

Introduction

S	A 54-year-old man has been found unconscious at his home by his relatives. The patient will be arriving by ambulance in 1 minute.
B	The patient suffers from depression and takes Saroten (Amitriptyline), a tricyclic antidepressant.
A	The patient was found unconscious. His relatives suspect that the patient took an overdose of Amitriptyline. The time of ingestion is unclear. The ambulance personnel have placed a nasal pharyngeal airway and two PVCs.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	Normal airway sounds, nasopharyngeal airway in place
Oral Cavity	Unremarkable

Breathing

SpO2%	95% with oxygen via mask
Respiratory Rate	12 breaths/min
Lung Auscultation	Normal breath sounds

Circulation

Blood Pressure	**60/35 mm Hg**
Heart Rate	**110 beats/min. With ventricular tachycardia: 210 beats/min**
Monitor EKG	**Wide QRS-complexes**, regular rhythm

Disability

Consciousness	**Unresponsive to voice and painful stimulus**
Eyes	**Pupils 6 mm, poor reaction to light**
Extremities	**No reaction to painful stimuli**

Exposure

Front	**Skin is red, warm and dry. No rash.**
Back	**Skin is red, warm and dry. No rash.**
Temperature	**37.8°C**

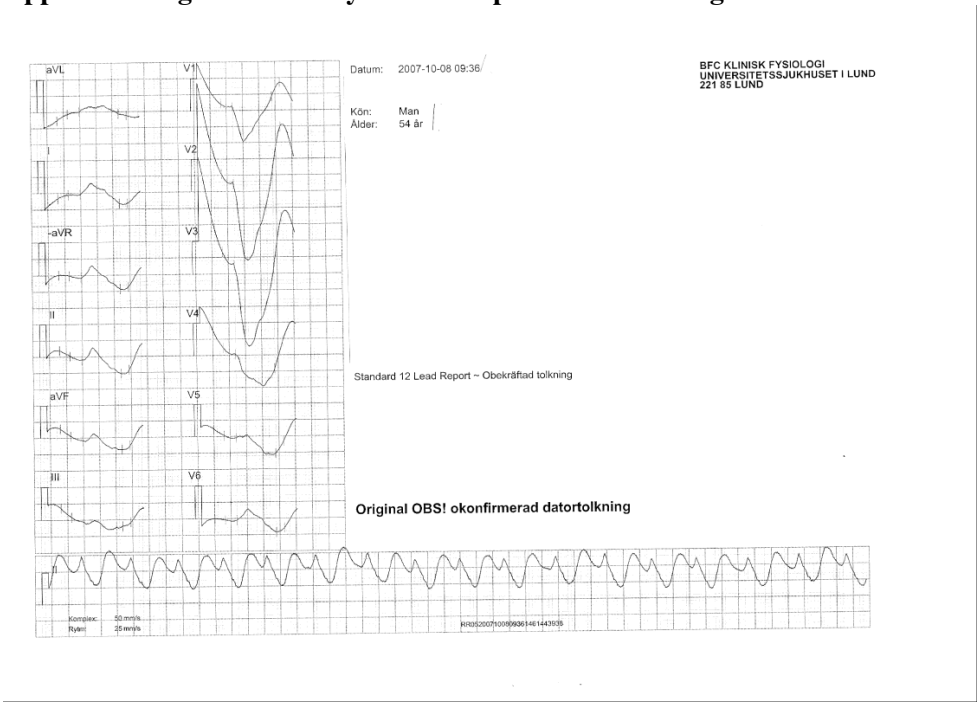
Adjuncts

Blood Tests	Provided if requested
EKG	EKG #1 is provided if requested. EKG #2 is provided if requested when the patient has developed ventricular tachycardia
Ultrasound	"No pericardial fluid, poor contractility. Large IVC. No free fluid."

Bedside Blood Tests

Blood Gas Values				
pH	7.28			
pCO_2	5.3	kPa	40	mm Hg
pO_2	14.9	kPa	151	mm Hg
Electrolyte Values				
Na^+	135	mmol/L		
K^+	4.7	mmol/L		
Ca^{2+}	1.2	mmol/L		
Cl^-	98	mmol/L		
Metabolite Values				
Glucose	7.6	mmol/L	137	mg/dl
Lactate	6.9	mmol/L	62.1	mg/dl
Oximetry Values				
Hb	148	g/L		
sO_2	99	%		
Other				
Base(Ecf)c	-7.6	mmol/L		
$HCO3^-$(P,st)c	18	mmol/L		

Appendix 1 Figure 13: Tricyclic Antidepressant Poisoning EKG #1



Appendix 1 Figure 14: Tricyclic Antidepressant Poisoning EKG #2

Emergency Interventions

1-Ringer's acetate 500 ml IV bolus	5-Adrenalin 20 microg IV
2-Sodium bicarbonate #1 200 ml IV bolus	6-Sodium chloride 3% #1 110 ml
3-Sodium bicarbonate #2 200 ml IV bolus	7-Sodium chloride 3% #2 110 ml
4-Magnesium 10 mmol IV over 2 min	8-Intralipid 100 ml IV
	9-ECMO

Comments

- Intervention 8: since intralipid is not available at one of the four sites, the maximum number of potential emergency interventions with eight when the scenario was simulated there.
- Intervention 9: ECMO stands for extracorporeal membrane oxygenation

7. Seizure

Manikin	**Running the Scenario**
• Supine • No oxygen mask • Two PVCs • Blanket covering the manikin	Within 1 minute of simulation onset, the patient has a tonic-clonic seizure. The patient continues to seize intermittently throughout the simulation.

Introduction

S	It's evening. An 84-year-old woman who presented to the emergency department has just had a seizure and she has been transferred to the resuscitation room.
B	The patient has been essentially healthy except a progressive anemia.
A	She underwent a colonoscopy this morning to investigate her progressive anemia. During the afternoon she became increasingly confused and vomited. Her husband called the ambulance. The patient received two PVCs during transport to the ED. She has been a Priority 2 until now when she developed a generalized seizure that lasted 1 minute. She has just been transferred to the resuscitation room.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	**Snoring breath sounds (disappear when receives nasopharyngeal airway, oropharyngeal airway or jaw thrust)**
Oral Cavity	Unremarkable

Breathing

SpO2%	**89% on room air**
Respiratory Rate	**6 breaths/min**
Lung Auscultation	Normal breath sounds

Circulation

Blood Pressure	**108/70 mm Hg**
Heart Rate	75 beats/min
Monitor EKG	Narrow QRS-complexes, regular rhythm

Disability

Consciousness	**Unreactive to voice or pain**
Eyes	Pupils 3 mm
Extremities	**Intermittent shaking of all 4 extremities; withdraws to pain**

Exposure

Front	Normal skin
Back	Normal skin
Temperature	36.8°C

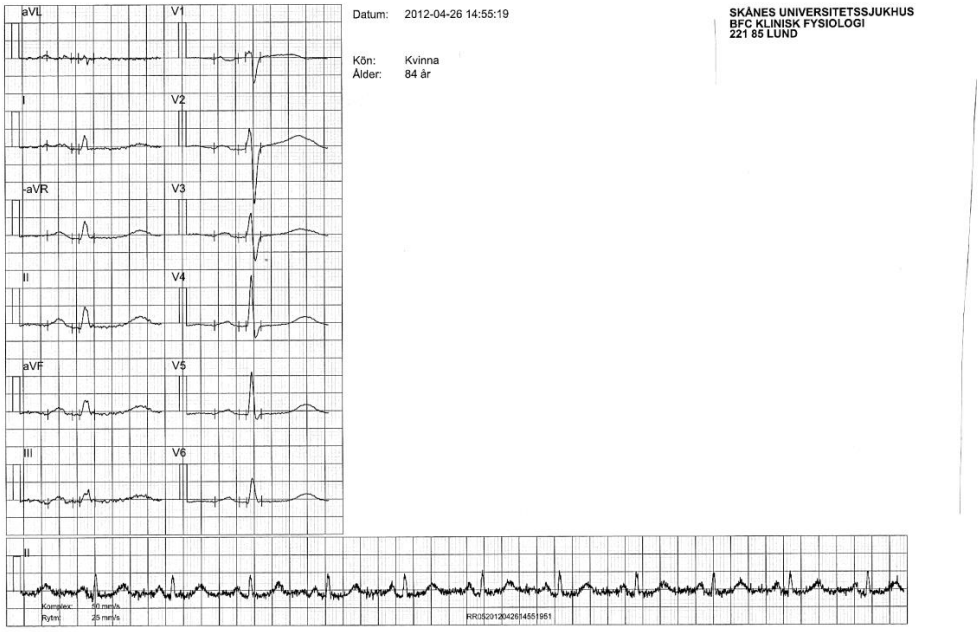
Adjuncts

Blood Tests	Provided if requested
EKG	Provided if requested
Ultrasound	Reveals no abnormalities

Bedside Blood Tests

Blood Gas Values				
pH	7.1			
pCO_2	7.2	kPa	54	mm Hg
pO_2	6.9	kPa	52	mm Hg
Electrolyte Values				
Na^+	115	mmol/L		
K^+	4.8	mmol/L		
Creatinine	58	µmol/L	0.65	mg/dl
Ca^{2+}	1.1	mmol/L		
Cl^-	79	mmol/L		
Metabolite Values				
Glucose	11.2	mmol/L	202	mg/dl
Lactate	8.2	mmol/L	73.8	mg/dl
Oximetry Values				
Hb	115	g/L		
sO_2	89.0	%		
Other				
Base(Ecf)c	-8.2	mmol/L		
$HCO3^-$(P,st)c	16	mmol/L		

Appendix 1 Figure 15: Seizure EKG



Emergency Interventions

1-Nasopharyngeal airway	6-Sodium chloride 3%: correct preparation
2-Supplemental oxygen	7-Sodium chloride 3%: 275 ml
3-Ventilation with bag-valve-mask	8-Benzodiazepine dose #2
4-Crystalloid 500 ml bolus	9-Keppra 60 mg/kg IV over 10 min
5-Benzodiazepine dose #1	10-Endotracheal intubation

Comment

- Intervention 9: alternatives to Keppra considered to be equivalent:
  - Fosfenytoin 15-20 mg/kg IV
  - Valproic acid 30-40 mg/kg IV

8. Increased Intracranial Pressure

Manikin	**Running the Scenario**
• Supine • Nasopharyngeal airway • Two PVCs • Blanket covering the manikin	• EtCO2 is 5.5 kPa initially

Introduction

S	A 54-year-old man has been found unconscious in his apartment.
B	The patient has no known prior illnesses and does not take any medications.
A	The patient suddenly started talking incoherently on the phone 1 hour ago. His son went to the patient's apartment and found the patient unconscious. The patient had vomited profusely in bed. During transport to the emergency room, the patient has received a nasopharyngeal airway and 2 PVCs.
R	"All yours" (remove the blanket)

Airway / C-spine

Head & Neck	No signs of trauma
Airway Sounds	Normal airway sounds, nasopharyngeal airway in place
Oral Cavity	Unremarkable

Breathing

SpO2%	**91% on room air**
Respiratory Rate	**10 breaths/min**
Lung Auscultation	Normal breath sounds

Circulation

Blood Pressure	**100/60 mm Hg**
Heart Rate	**135 beats/min**
Monitor EKG	Narrow QRS-complexes, regular rhythm

Disability

Consciousness	**No verbal response to voice or pain**
Eyes	Right pupil 3 mm, reacts to light **Left pupil 6 mm, unresponsive to light**
Extremities	Withdraws left arm + left leg to pain **Right arm and right leg do not react to pain**

Exposure

Front	Normal skin appearance
Back	Normal skin appearance
Temperature	**38.0°C**

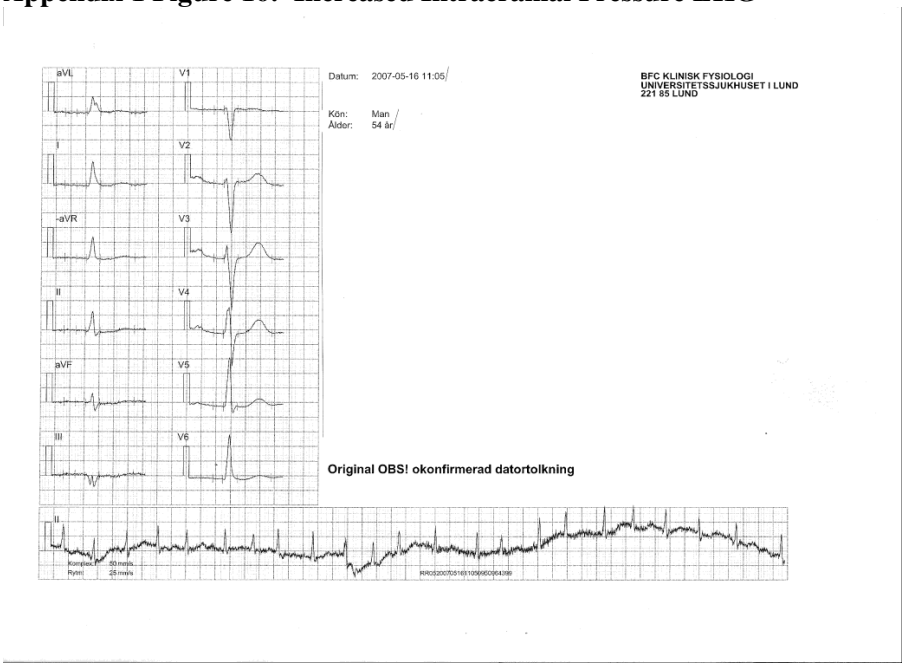
Adjuncts

Blood Tests	Provided if requested
EKG	Provided if requested
Ultrasound	"Reveals no abnormalities"

Bedside Blood Tests

Blood Gas Values				
pH	7.35			
pCO_2	6.2	kPa	46	mm Hg
pO_2	5.2	kPa	39	mm Hg
Electrolyte Values				
Na^+	141	mmol/L		
K^+	4.6	mmol/L		
Creatinine	70	µmol/L	0.79	mg/dl
Ca^{2+}	1.19	mmol/L		
Cl^-	105	mmol/L		
Metabolite Values				
Glucose	9.2	mmol/L	166	mg/dl
Lactate	1.5	mmol/L	13.5	mg/dl
Oximetry Values				
Hb	136	g/L		
sO_2	67.0	%		
Other				
Base(Ecf)c	+0.8	mmol/L		
$HCO3^-$(P,st)c	24	mmol/L		

Appendix 1 Figure 16: Increased Intracranial Pressure EKG



Emergency Interventions

1-Oxygen ≥ 10 L/min via oxygen mask	5-Paracetamol 1 g IV
2-Elevate the head of the bed	6-Sodium chloride 3% 275 ml IV bolus
3-Bag-valve-mask ventilation to EtCO3 3.5	7-Endotracheal intubation
4-Sodium chloride 500 ml IV bolus	8-Head CT

IV. Simulations–Methods

Manikin

Given that the simulations were carried out in-situ in actual resuscitation rooms, a manikin that could quickly be wheeled in and out of the resuscitation room was required. Vital signs were generated by a computer and displayed on a screen, hence a simple manikin without spontaneous respiratory activity, palpable pulse or electrical rhythm generation was deemed suitable (Laerdal Extri Kelly®). The same manikin was used in all emergency departments.

Vital Signs

Computer-generated vital signs were displayed on the screen used during actual clinical practice or on a screen of similar size placed in a similar location.

Duration

Based on results from a pilot study,[58] the optimal simulation duration was determined to be 15 minutes. During the simulations, infusions were considered to have been completely given once initiated in order to minimize the amount of time that personnel on clinical duty were involved in the trial.

Incomplete Simulations

Simulations that could not be completed due to actual emergencies were excluded from the study, and the data discarded.

Sample Size Calculation

When ethics approval was sought (Dnr 2013/858), no data was available to estimate sample size, and we sought ethical approval to carry out the study in all five EDs in Southern Sweden.

Appendix 1 Table 1: Results from a Pilot Study of Crisis Checklists

% Emergency Interventions	Without Checklist	With Checklist
Mean	48	76
Median	44	83
Standard Deviation	23	20

Appendix Table 1 displays the results obtained from a pilot study of crisis checklists in the ED performed during the spring of 2016[58]

The minimum sample size for each group was calculated using the following formula for comparison of two means: $(u + v)^2 (\sigma_1^2 + \sigma_0^2) / (\mu_1 - \mu_0)^2$
where:
$\mu_1 - \mu_0$: difference between the means
σ_1, σ_0: standard deviations

Based on this equation, performing each scenario twice (with and without checklist access) in three EDs (3 x 8 scenarios with and 3 x 8 scenarios without checklist access) would be sufficient to detect a clinically meaningful difference of 20% in performed emergency interventions with a power of 0.80 and a Type I error probability of 0.05. However, given the uncertainty as to whether the study could be performed in-situ despite on-going clinical duties, we planned to carry out the study in four EDs.

Randomization of Teams to Scenarios and Checklists

Teams consisted of local personnel assigned to manage priority 1 patients in the resuscitation room on the study day. Should a priority 1 patient present during the course of a simulation, the simulation would need to be interrupted unless another team could be mobilized to manage the patient. In order to increase the likelihood that each team could perform two simulations, an extra resuscitation team was scheduled to work in the ED during the mornings of the study period in two of the four EDs. Yet there was no guaranty that a given team would have the opportunity to perform one or two simulations without interruption. In addition, the exact composition of each team was at the discretion of the local staff in charge of resource allocation in the ED on the given day. Team composition could therefore not be ascertained in advance.

Team allocation to scenario and checklist access was designed to satisfy the following criteria:

- randomized sequence according to which the scenarios (with and without checklist access) were run in each ED
- each scenario would be simulated at least twice (once with and once without checklist access) in each ED
- teams performing two simulations would run one with checklist access and one without
- no team member would perform the same scenario more than once
- an allocation system that would allow for teams to perform only one simulation and palliate for situations in which the simulation had to be interrupted due to clinical duties

Team allocation to scenario and checklist access was determined in the following manner:

- The sequence according to which the eight scenarios were carried out at each ED was determined through a permuted block randomization process using the Excel RAND function.
- Whether the first simulation was run with checklist access (+) or without (-) in each ED was alternated, ensuring that the first simulation was run with checklist access in two EDs and that the first simulation was run without checklist access in the other two EDs.
- Checklist access was alternated thereafter. For example, if the scenario sequence was 5-3-2-8-4-6-1-7 and the first scenario was run with checklist access (+), the following sequence was generated: 5+; 5-; 3+; 3-; 2+; 2-; 8+; 8-; 4+; 4-; 6+; 6-; 1+; 1-; 7+; 7-. This sequence can be thought of as a stack of 16 cards, with the top card representing scenario 5 with checklist access and bottom card scenario 7 without checklist access.
- For a given team, the allocated scenario was the highest card in the stack representing a scenario that none of the team members had performed previously.
- Once a team had successfully carried out a whole simulation, the corresponding card was discarded. If the team had to interrupt the scenario prior to its completion, the card was left in the stack at its original position, until a team consisting of different personnel could perform the scenario.
- When a given team could perform a second simulation, the allocated scenario was the highest card in the stack representing a scenario that none of the team members had performed previously and with a different checklist access than during the first simulation.

Appendix 1 Table 2: Scenario Sequences for Each ED

ED1	ED2	ED3	ED4
8+	3-	5+	7-
8-	3+	5-	7+
1+	6-	6+	1-
1-	6+	6-	1+
4+	5-	8+	3-
4-	5+	8-	3+
6+	4-	3+	8-
6-	4+	3-	8+
7+	2-	1+	6-
7-	2+	1-	6+
3+	1-	7+	5-
3-	1+	7-	5+
5+	8-	2+	4-
5-	8+	2-	4+
2+	7-	4+	2-
2-	7+	4-	2+

This table provides the sequences according to which the eight scenarios were run in each of the four EDs. The + symbolizes that the scenario was run with checklist access, the – that the scenario was run without checklist access. For one ED, simulations were performed over the course of three weeks until all 16 simulations had been performed. For the other three EDs, all simulations were performed over the course of five consecutive weekdays, with the goal of performing four simulations per day and an extra day scheduled to perform remaining or additional simulations.

Appendix 1 Table 3: Scenario Sequence for Additional Simulations in Three EDs

ED2	ED3	ED4
1-	3+	2-
1+	3-	2+
5-	5+	7-
5+	5-	7+
3-	8+	1-
3+	8-	1+
6-	2+	5-
6+	2-	5+
8-	6+	4-
8+	6-	4+
2-	4+	6-
2+	4-	6+
7-	7+	8-
7+	7-	8+
4-	1+	3-
4+	1-	3+

For three EDs, all simulations were performed over the course of five consecutive weekdays, with the goal of performing four simulations per day and an extra day scheduled to perform remaining or additional simulations. Sequences were randomly generated in the event that additional simulations could be performed. This table provides these additional sequences. The + symbolizes that the scenario was run with checklist access, the – that the scenario was run without checklist access.

Investigator Protocol

The investigator who led the simulations was not blinded to whether the team had access to checklists or not. In order to minimize the risk of influencing team performance, the investigator had to follow a strict protocol. Adherence to protocol was evaluated during the video review by two investigators.

Prior to Reading the Introduction to the Study

When the lead nurse and physician in the ED deemed that the timing was most suitable, a resuscitation team was gathered in the resuscitation room without being informed about the nature of the scenario. Team members were enrolled at this point in the study and signed an informed consent form. The scenario to be used was determined based on the generated scenario sequence and the composition of the team (see Scenario Sequence).

Introduction to the Study

The investigor who led the simulations then read out introductory information to all team members that emphasized:

- that the diagnosis would be readily apparent from the introductory information, and that the simulation would focus on treatment
- that team members were meant to treat the manikin as a real patient, e.g. by placing an oxygen-mask on the patient, injecting medications through the peripheral venous catheter
- that team members were to locate actual equipment and medications, and would then receive training equipment/placebo

The following is a translation into English of the text that the investigator running the simulations read out to all team members:

"1-The focus during the scenario will be on treatment. The patient's diagnosis will be quite obvious from the report you receive.
2-You do not have the time to carry out a Sign-In, but instead start direcly with assessing and treating the patient.
3-Treat the patient as if he or she were a real patient. Insert a PVC if the patient does not already have one. Give fluids and drugs via the PVC; the fluid you give is collected under the bed. If you want to give IM treatment, use this cushion.
4-I can answer questions regarding respiratory rate, sounds on chest auscultation, level of consciousness, skin findings, temperature. Vital parameters appear on the screen. I will provide a 12-lead ECG and bedside blood tests upon on request.

In regard to medications:
- If the medication is located in the emergency room, you must find the medication, show it to me, then you will receive a placebo to be given to the patient.
- If the medication is not in the emergency room, you just need to tell me where it is, then you will receive a placebo
- If the medication needs to be injected over 10-20 minutes, it is enough that you start the injection or infusion and then state the duration of the injection or infusion
- You can then ask if the medication had any effect

In regard to equipment, I can provide practice equipment."

If the team was randomized to no-checklist access, the following was read out to the team members: "You may use all resources that you normally use."

If the team was randomized to checklist access, the following was read out to the team members: "During this simulation, you will have access to a checklist that will appear on the screen after the simulation has started. You are meant to use the checklist when managing the case. You can trust the checklist content, it is based on the latest literature and reviewed by four specialists in emergency medicine."

At this point, a demonstration checklist (management of hyperkalemia) is shown on the screen and the following text is read out: "The checklist is controlled with this iPad."

The team is asked to select a team member (a nurse or a medical secretary) whose task it is to go through the checklist. This team member is then asked to open a couple of popover windows by pressing on the corresponding popover icon. The following text is read out to this team member: "One of your tasks during the simulation will be to go through all the items on the checklist and see if the patient meets the criteria for receiving certain treatments. This means opening all the popover windows in the checklist one by one. Of course, you can also contribute to giving medicines and doing other tasks."

Introduction to the Scenario
The introduction to the scenario was then read to the team members. If the team was randomized to checklist access, the relevant checklist was brought forth on the computer tablet upon starting the simulation.

Investigor Leading the Simulations: Required

- The investigor leading the simulations was required to provide clinical information (e.g. how the patient answers questions, skin colour, findings on examination of the mouth etc.), EKG, blood tests immediately upon request.
- The investigor leading the simulations was required to state that treatments could be considered fully administered once administration has begun, and to provide information about their clinical effects.

Investigor Leading the Simulations: Allowed

- The investigor leading the simulations was allowed to repeat the instruction to treat the manikin as a real patient, i.e. administer medications via the PVC, placing an oxygen mask on the patient.
- The investigor leading the simulations was allowed to ask the team to clarify/specify which treatments that had been given and which blood tests that had been taken.

Investigor Leading the Simulations: Forbidden

- The investigor leading the simulations was not allowed to enjoin the team to use the checklist once the simulation had begun.
- The team was meant to decide whether to give or not give an intervention without assistance from other personnel. The investigator leading the simulations was not allowed to convey approval from external personnel regarding the administration of specific interventions.

Protocol Violations

All simulations were independently reviewed by two investigators for protocol violations. There were two protocol violations that occurred within the 15-minute simulation-windows:

- When the nurse could not find the Sodium Bicarbonate, the investigor leading the simulation said: "look at the checklist" where it stated where the Sodium Bicarbonate was located. Sodium Bicarbonate was successfully located and administered but no point was given for this measure given the protocol violation.
- A nurse and a physician were confused about how fast insulin should be given, and were about to fetch an infusion-pump. The investigor leading the simulation said: "look at the checklist". No point was given for insulin administration.

V. Simulations–Results

Simulation Dates

The simulations were performed

- Emergency Department 1: between the 19th of July and 28th of August 2019
- Emergency Department 2: between the 18th and 22nd of November 2019
- Emergency Department 3: between the 25th and 29th of November 2019
- Emergency Department 4: between the 29th of January and 4th of February 2020

Appendix 1 Table 4: Scenarios Performed by Each Team

Team	ED	First Scenario	Second Scenario
1	1	8+	1-
2	1	4+	6-
3	1	4-	6+
4	1	8-	1+
5	1	7+	
6	1	7-	3+
7	1	5+	
8	1	3-	2+
9	1	5-	
10	1	2-	
11	2	3-	6+
12	2	3+	6-
13	2	5-	4+
14	2	5+	4-
15	2	2-	1+
16	2	2+	1-
17	2	8-	7+
18	2	8+	7-
19	2	1-	5+
20	2	1+	5-
21	3	5+	6-
22	3	5-	6+
23	3	8+	3-
24	3	8-	3+
25	3	1+	7-
26	3	1-	7+
27	3	2+	4-
28	3	2-	4+
29	3	3+	8-
30	3	5-	2+
31	4	7-	1+
32	4	7+	1-
33	4	3-	
34	4	8+	
35	4	3+	8-
36	4	6-	5+
37	4	6+	5-
38	4	4-	2+
39	4	4+	2-

40	4	7-	1+
41	4	7+	1-

This table provides the scenario or scenarios performed by each team. Thirty-five of the 41 teams performed two simulations, one with (+) and one without (-) checklist access. Six of the 41 teams were only able to perform one simulation due to the need to take care of actual patients in the resuscitation room. No team member performed the same scenario twice.

Appendix 1 Table 5: Team Composition

Team Composition				Number			
Physician	**Nurse**	**Nursing Assistant**	**Medical Secretary**	**ED1**	**ED2**	**ED3**	**ED4**
1	1	1	1	0	8	10	0
1	2	0	1	0	2	0	0
1	2	1	0	6	0	0	7
2	2	1	0	0	0	0	3
1	2	2	0	3	0	0	0
1	3	1	0	0	0	0	1
1	3	0	0	1	0	0	0
Total				10	10	10	11

Each of the 41 teams were composed of 4 or 5 healthcare personnel. In two EDs, the standard team consisted in one physician, one nurse, one nursing assistant and one medical secretary (18 teams), but in two teams a nurse replaced the nursing assistant. In the other two EDs, the standard team consisted in one physician, two nurses and one nursing assistant (13 teams), but three teams featured an additional physician, three teams an additional nursing assistant, one team an additional nurse, and in one team a nurse replaced the nursing assistant.

Appendix 1 Table 6: Number of Simulations Performed by Each Participant

Number of simulations performed by a participant	**Numbers of participants**
1	13
2	101
3	2
4	17
5	1
6	4

This table displays the number of simulations performed by the participants in the study. The physicians, nurses, nursing assistants and secretaries that participated in the study were those staffing the resuscitation teams on the day the study was carried out. Some personnel were part of the resuscitation team during more than one study day and hence performed more than two simulations.

Appendix 1 Table 7: Characteristics of the Teams Performing Only One Scenario

Team	Size	Physician Age (years)	Physician Experience (1-5)	Senior Nurse Age (years)	Senior Nurse Experience (1-5)
5+	5	35	2	48	5
7+	4	33	2	37	4

9-	4	28	2	49	5
10-	4	42	4	52	5
33-	5	39	3	44	4
34+	4	39	3	44	4

The three teams that only performed one scenario with checklist access (+) did not differ significantly from the three teams that only performed one scenario without checklist access (-) in regard to team size, physician age, physician experience, senior nurse age or senior nurse experience. Experience was graded on a 1-5 scale where 1 indicates < 1 year of experience, 2 1-4 years of experience, 3 5-9 years of experience, 4 10-14 years of experience, and 5 ≥ 15 years of experience.

Simulation Termination and Duration

Simulations were terminated when all emergency interventions had been performed, when the team expressed that they could not think of any other intervention to perform, or when 15 minutes has elapsed, whichever came first. The following table provides a break-down of the reasons for simulation termination.

Appendix 1 Table 8: Grounds for Simulation Termination

	Checklist Access (n=38)	No Checklist Access (n=38)
All interventions performed	14 (37%)	0 (0%)
No further ideas	4 (10%)	12 (32%)
15 minutes elapsed	20 (53%)	26 (68%)

The following table provides a break-down of simulation duration according to checklist access.

Appendix 1 Table 9: Simulation Duration (seconds)

	Checklist Access (n=38)	No Checklist Access (n=38)
Median	900	900
Mean	827	863
Standard deviation	120	78
Minimum	358	597
Maximum	900	900

There was no statistically significant difference between the simulation durations with or without checklist access (P=0.12).

Appendix 1 Table 10: Simulation Duration (seconds) when Teams Could Not Think of Additional Interventions

	Checklist Access (n=4)	No Checklist Access (n=12)
Median	797	807
Mean	796	785
Standard deviation	54	102
Minimum	729	597
Maximum	861	896

There was statistically significant difference between the simulation durations with or without checklist access (P=0.77).

Usual Cognitive Aids

Usual cognitive aids were exclusively used to guide the performance of first-line and non-first-line interventions, not for diagnostic purposes. Teams that were randomized to no checklist access were explicitly allowed to use whatever usual cognitive aids they had at their disposal for whatever purpose they saw fit. Teams that were randomized to checklist access were explicitly encouraged to use the checklist. The following table provides a breakdown of the type of usual cognitive aids used, depending on whether the teams had checklist access or not.

Appendix 1 Table 11: Use of Usual Cognitive Aids

Type of Aid Used	Checklist Access (n=38)	No Checklist Access (n=38)
Internet	2	12
Pocket-Book	2	6
Printed Card	2	0
Internet + Pocket-book	0	7
Internet + Printed Card	0	1
One or more aids	6	26

VI. Analysis According to Mixed Effects Proportional Odds Regression

The following table displays the observed proportions of teams, with and without checklist access, who performed from 1 to 10 emergency interventions. The table also displays the corresponding expected values, along with associated 95% confidence intervals, that were derived from the observed data under a proportional odds regression model. The observed and expected percentages are analogous to those provided in simple linear regression. In a regression of one continuous response variable y against an independent variable x, the observed results are the scatter plot of the actual observations (x, y). The expected response is the estimated regression line, which is the optimal straight-line fit of the relationship between y and x under the model assumption that the true expected relationship is linear. In this paper we are using a mixed effects proportional odds regression model. The close agreement between the observed and expected percentages in this table indicates that this model is appropriate for our data. There was a profound difference in the number of indicated interventions performed by teams that did, and did not, use the checklist ($P = 7.5 \times 10\text{-}8$). The 95% confidence intervals for these probabilities did not overlap for all but the five- and 10-interventions outcomes.

Appendix 1 Table 12: Effect of checklists on the number of indicated emergency interventions performed within 15 minutes

Number of interventions performed	**Teams Without Checklist Access (n=38)**			**Teams With Checklist Access (n=38)**		
	No. (%)		95% confidence intervals	No. (%)		95% confidence intervals
	Observed	Expected		Observed	Expected	
1	2 (5.3%)	5.1%	(1.2% - 20%)	0 (0.0%)	0.1%	(0.0% - 0.8%)
2	7 (18.4%)	18.1%	(5.6% - 31%)	0 (0.0%)	0.4%	(0.0% - 1.1%)
3	14 (36.8%)	36.4%	(19% - 53%)	0 (0.0%)	1.8%	(0.0% - 4.3%)
4	9 (23.7%)	25.4%	(12% - 39%)	2 (5.3%)	6.0%	(0.1% - 12%)
5	3 (7.9%)	10.3%	(1.8% - 19%)	7 (18.4%)	16.1%	(5.9% - 26%)
6	1 (2.6%)	2.7%	(0.0% - 6.0%)	8 (21.1%)	19.3%	(7.0% - 32%)
7	1 (2.6%)	1.4%	(0.0% - 3.4%)	11 (28.9%)	28.4%	(13% - 43%)
8	1 (2.6%)	0.3%	(0.0% - 0.9%)	4 (10.5%)	12.6%	(2.2% - 23%)
9	0 (0.0%)	0.2%	(0.0% - 0.7%)	5 (13.2%)	12.8%	(1.4% - 24%)
10	0 (0.0%)	0.0%	(0.0% - 0.6%)	1 (2.6%)	2.6%	(0.3% - 17%)
1-10	38 (100%)	100%		38 (100%)	100%	

VII. Analysis of Factors Potentially Influencing Performance

Appendix 1 Table 13: Effect of Factors on Performance

Potential Factors	Significance
Emergency Department	P = 0.90
Senior Physician Experience	P = 0.77
Senior Physician is a Specialist	P = 0.87
Senior Nurse Experience	P = 0.38
Checklist Access	P ≤ 0.0005
Scenario	P = 0.006

Appendix 1 Table 14: Interactions between Factors and Checklist Access on Performance

Potential Interactions	Significance
Checklist Access x Scenario Type	P = 0.27
Checklist Access x Emergency Department	P = 0.48
Checklist Access x Senior Physician Experience	P = 0.50
Checklist Access x Senior Physician is a Specialist	P = 0.12
Checklist Access x Senior Nurse Experience	P = 0.09
Checklist Access x Cognitive Aid Use	P = 0.72

The P-value reported under the column "Significance" is for the interaction term(s).

VII. Dangerous or Inappropriate Interventions

Definitions

- "Dangerous" interventions were defined as administered interventions that are potentially harmful, such as administering an intravenous bolus of adrenalin exceeding 100 ug.
- "Inappropriate" interventions were defined as interventions ordered by the physician that are not suitable to the situation, such as ordering an antidote for a poisoning other than the one that the patient was suffering from.

The following table lists dangerous or inappropriate interventions according to scenario and checklist access. All but one of these interventions occurred during simulations where the team did not have access to the checklists.

Appendix 1 Table 15: Dangerous or Inappropriate Interventions

Situation	Intervention	Checklist Access	
		No	Yes
Anaphylactic chock	Adrenalin 0.3 - 0.5 mg IV push	1	1
Life-threatening asthma exacerbation with agitation	Diazepam IV push	3	0
	Morphine IV push	2	0
	Theophylline nebulized	1	0
Calcium Channel Blocker Poisoning with shock and bradycardia	Physostigmin	1	0
	Adrenalin 0.2 mg IV push	1	0
	Sodium bicarbonate infusion	1	0
Tricyclic Antidepressant Poisoning	Tribonate infusion	2	0
	Calcium gluconate infusion	1	0
Seizure from hyponatremic encephalopathy	NaCl 23% 20 ml IV push	1	0
Total		**14**	**1**

Dryver E, *et al. BMJ Qual Saf* 2021;0:1–9. doi: 10.1136/bmjqs-2020-012740

VIII. Diagnostic Awareness

It may be hypothesized that teams randomized to checklist access benefitted from knowing the diagnosis from the start, while the performance of teams without checklist access was hampered by diagnostic uncertainty. We argue that any potential delay in diagnostic awareness among teams randomized to no checklist access is unlikely, for the following three reasons.

First, all teams were informed prior to the simulations that the diagnosis would be readily apparent from the information provided at the outset (Section V). The diagnosis was readily apparent from the scenario introduction and sentinel clinical findings provided during the primary survey (Section III). For example, teams were informed that the patient was severely allergic to wasps and had just been stung by a wasp prior to the anaphylaxis scenario; that the patient had vomited a mixture of fresh blood and coffee grounds throughout the night prior to the upper gastrointestinal hemorrhage scenario; that the patient suffered from depression, had written a suicide note, and that 30 tablets of Cardizem Retard were missing prior to the calcium antagonist poisoning scenario. Prior to the seizure scenario, teams were informed that the patient had just suffered from a seizure, and teams were informed that seizures were recurring throughout the simulation.

Second, the video recordings provide objective proof that the team physician was aware of the diagnosis in one of two ways:

- the physician states the diagnosis (e.g. “so this patient has anaphylaxis”)
- the physician orders first-line diagnosis-specific interventions; for example, ordering a blood transfusion is proof that the physician’s working diagnosis is hemorrhage; ordering blood cultures is proof that the physician suspects an infection

The following table lists the terms used by the physicians in the context of stating the patient’s diagnosis and the first-line diagnosis-specific interventions ordered by the physicians that were considered proof of diagnostic awareness.

Appendix 1 Table 16: Proof of Diagnostic Awareness

Scenario	Terms	Interventions
Anaphylaxis	“Anaphylaxis” or “Anaphylactic shock”	• Adrenalin i.m.
Asthma	“Asthma”	• Bronchodilator nebulized
Upper Gastrointestinal Bleed	“Gastrointestinal” or “GI” + “bleeding”	• Blood transfusion • Esomeprazole i.v. push
Sepsis	“Sepsis” or “Septic shock”	• Blood cultures
Calcium Channel Blocker Poisoning	“Calcium antagonist” or “Calcium blocker”	• Calcium infusion
Tricyclic Antidepressant Poisoning	“Tricyclic”	• Sodium bicarbonate infusion
Seizure from Hyponatremic Encephalopathy	“Seizure” or “Status”	• Benzodiazepine i.v. push • 3% Sodium chloride infusion
Increased Intracranial Pressure	“Brain” + “bleeding”	• Acute head CT

Third, in 12 of the 38 simulations performed without checklist access, the simulation was terminated when the teams clearly expressed that they had no further ideas for indicated emergency interventions (Appendix 1 Table 6). It can therefore not be argued that these teams lacked time to perform interventions after having become aware of the diagnosis. In 13 of the 26 simulations without checklist access lasting 15 minutes, no interventions were performed during the final 5 minutes. Such inactivity on the part of the team is hard to explain other than by positing that the team could not think of an intervention to perform or could not perform it (e.g. by not knowing how to find, prepare or dose the medication). Finally, in the remaining 13 simulations, diagnostic awareness could be confirmed within 90 seconds in 6 simulations and between 2 and 5 minutes into the scenario in 6 simulations. These numbers suggest that any potential delay in treatment due to diagnostic uncertainty was minor.

It should be emphasized that actual diagnostic awareness preceded the time at which it could be confirmed using the video recordings. For example, we randomly ascertained, by reviewing the video recordings, the time of proof of diagnostic awareness in a team with checklist access randomized to the upper gastrointestinal bleeding scenario. Time at which blood transfusion was ordered was 127 seconds into the scenario, yet the team was arguably aware of the diagnosis from simulation start. In 6 of the 7 simulations where proof of diagnostic awareness occurred beyond 2 minutes from scenario start, teams performed at least one emergency interventions prior to the time of proof of diagnostic awareness.

Appendix 1 Table 17: Characteristics of Simulations Without Checklist Access Lasting 15 Minutes During Which Interventions Were Performed During the Final 5 Minutes

Scenario	Time of PDA[1] (sec)	Number of indicated interventions performed	
		Prior to PDA[1]	After PDA[1]
Seizure	8	0	6
Upper gastrointestinal bleed	25	0	4
Anaphylaxis	63	0	4
Anaphylaxis	66	0	4
Seizure	79	2	6
Anaphylaxis	87	0	4
Asthma	166	1	2
Seizure	176	2	3
Calcium channel blocker overdose	187	1	3
Tricyclic antidepressant overdose	195	0	3
Seizure	228	1	6
Calcium channel blocker overdose	267	1	1
Calcium channel blocker overdose	706	1	2

1-PDA: Proof of Diagnostic Awareness (see Appendix 1 Table 16)

The impact of checklist access on the percentage of indicated emergency interventions was reanalyzed after replacing the percentages of indicated emergency interventions performed during these 13 simulations by 100%. Teams with checklist access still outperformed teams without checklist access: median percentage of interventions performed 50.0% (95% CI 37.5% - 78.6%) without checklist access and 85.7% (95% CI 77.8% - 87.5%) with checklist access (P=0.01).

When it comes to the status epilepticus scenario, all teams were informed that the patient had just suffered from a seizure, and all teams were informed that seizures were recurring throughout the simulation. It is hard to conceive that teams were not aware that the patient was suffering from seizures, even if the teams were not provided with a checklist labeled "Seizure." Four of the above 13 simulations were seizure scenarios. If we replace the percentages of indicated emergency interventions performed for the remaining 9 simulations by 100%, we obtain median percentage of interventions performed 50.0% (95% CI 37.5% - 58.6%) without checklist access and 85.7% (95% CI 77.8% – 87.5%) with checklist access (P=0.000).

These facts argue against the hypothesis that the performance of teams randomized to no checklist access was hampered by diagnostic uncertainty.

IX. Survey

Appendix 1 Table 18: Participants' Perceptions of the Checklists Used in the Study

Survey Statement	Response Score
The checklist helped me to manage the case	6 +/- 0.80
The checklist was useful	6 +/- 0.58
I would use the checklist if I got a similar case in reality	6 +/- 0.69
If I were the patient affected by the condition in the scenario, I would like the team to use the checklist	6 +/- 0.69
The checklist did not interfere with the management of the case	6 +/- 0.89

A total of 158 surveys (40 from physicians, 60 from nurses, 38 from nursing assistants and 20 from medical secretaries) were filled out by members of teams who had carried out a simulation with checklist access. Response scores, expressed as median +/- standard deviation, were on a Likert scale that ranged from 1 (disagree strongly) to 6 (agree strongly).

Appendix 1 Table 19: Survey Responses According to Profession

Survey Statement	Response Score			
	Physician (n=40)	**Nurse (n=60)**	**Nursing assistant (n=38)**	**Medical secretary (n=20)**
The checklist helped me to manage the case	5 +/-0.8	6 +/-0.6	5 +/-1.0	6 +/-0.5
The checklist was useful	6 +/-0.7	6 +/-0.5	6 +/-0.6	6 +/-0.5
I would use the checklists if I got a similar case in reality	6 +/-0.8	6 +/-0.5	6 +/-0.8	6 +/-0.4
If I were the patient affected by the condition in the scenario, I would like the team to use the checklist	6 +/-0.9	6 +/-0.5	6 +/-0.7	6 +/-0.6
The checklist did not interfere with the management of the case	5 +/-1.0	6 +/-0.8	6 +/-0.7	5.5 +/-1.0

A total of 158 surveys were filled out by members of teams who had carried out a simulation with checklist access. Personnel were asked to indicate to what degree they agreed with five statements, on a Likert scale of 1 (disagree strongly) to 6 (agree strongly). Response scores are expressed as means +/- standard deviation.

Appendix 1 Table 20: Survey Responses According among Physicians

Survey Statement	Response Score		
	Specialists in EM (n = 4)	**Residents in EM (n = 27)**	**Other Residents (n = 4)**
The checklist helped me to manage the case	5 +/- 1.1	6 +/- 0.7	6 +/- 0.5
The checklist was useful	5 +/- 0.6	6 +/- 0.7	5 +/- 0.5
I would use the checklists if I got a similar case in reality	5 +/- 0.6	6 +/- 0.9	6 +/- 0.5
If I were the patient affected by the condition in the scenario, I would like the team to use the checklist	5 +/- 0.6	6 +/- 1.1	6 +/- 0.5
The checklist did not interfere with the management of the case	4.5 +/- 0.8	5 +/- 1.1	6 +/- 1.3

A total of 35 surveys were filled out by either specialists in Emergency Medicine (EM), residents in EM or residents in another speciality. Personnel were asked to indicate to what degree they agreed with five statements, on a Likert scale of 1 (disagree strongly) to 6 (agree strongly). Response scores are expressed as means +/- standard deviation.

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