CARDIOPULMONARY RESUSCITATION (CPR)

What does CPR stands for?

- C = Cardio (heart)
- P = Pulmonary (lungs)
- R = Resuscitation (recover)

DEFINITION

- Cardio pulmonary resuscitation (CPR) is a technique of basic life support for the purpose of oxygenation to the heart, lungs and brain until and the appropriate medical treatment can come and restore the normal cardiopulmonary function.

PURPOSE

- Restore cardiopulmonary functioning.
- Prevent irreversible brain damage from anoxia.

INDICATION

Cardio vascular disorders

CAD, congenital heart diseases , coronary
embolism, cardiac rupture & dissection

Pulmonary causes

pulmonary embolism, pulmonary edema, asphyxia due to drowning or foreign body

Metabolic causes

hypoglycemia, electrolyte imbalances

Fluid imbalance

extensive hemorrhage, hypotension, shock

Neurological causes

brain injuries, massive cva

Poisons substance and drug overdose

co poisoning, propanolol over dose

Other causes

electrical shock, hypothermia, narcotic overdose

Diagnosis of cardiac arrest (TRIAD):

1) Loss of **consciousness**.
2) Loss of apical & central **pulsations**
 (carotid, femoral).
3) **Apnea**.

PHASES OF THE CARDIO PULMONARY RESUSCITATION:

Phase-1 *Basic life support*

C= circulation

A= Airway

B= Breathing

Phase-2 *Advance cardiac life support*

D= Drugs

E= ECG

F= fibrillation

Phase-3 *Prolonged life support*

Post resuscitation care

BLS

- What is basic life support (**BLS**)?

  It is life support **without** the use of **special equipment.**

- What is Advanced Life Support (**ACLS**)?

  It is life support **with** the use of **special equipment** (eg. Airway, endotracheal tube, defibrillator).

1) EARLY RECOGNITION

1) Unresponsiveness

- Check the victim for a response.
- Shake shoulders gently
- Ask “Are you all right?'' *If there is no response, help*

2) No breathing or no normal breathing (i.e, only gasping) *Look, Listen ,Feel*

3) No pulse felt within 10 seconds.

2) CPR Sequence

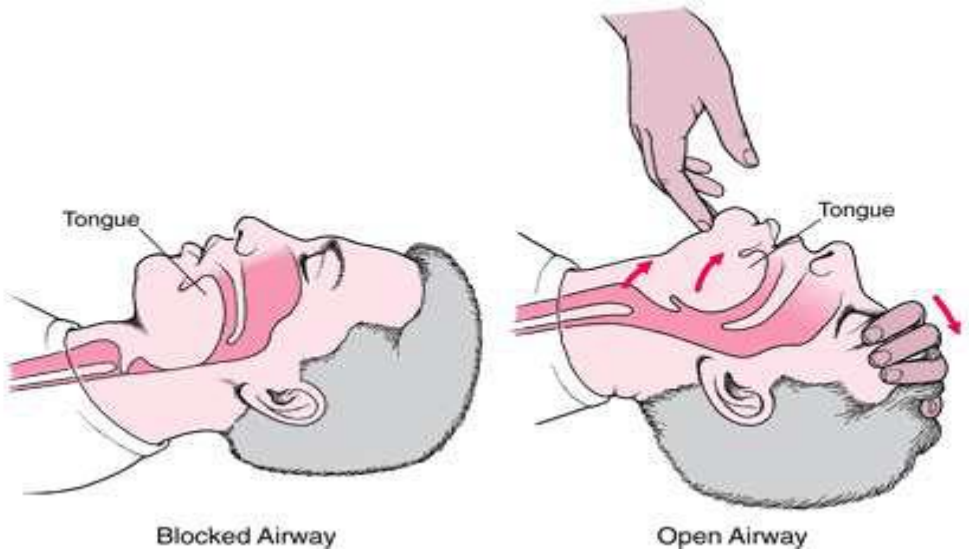
(A) = Airway

Loss of consciousness often results in airway obstruction due to loss of tone in the muscles of the airway and falling back of the tongue.

Basic techniques for airway patency:

1) Head tilt, chin lift:

one hand is placed on the forehead and the other on the chin the head is tilted upwards to cause anterior displacement of the tongue.



2) Jaw thrust:

3) Finger sweep:

Sweep out foreign body in the mouth by index finger (in unconscious pt only.

(B) = Breathing

Rescue breathing can be mouth-to-mouth breathing or mouth-to-nose breathing if the mouth is seriously injured or can't be opened.

Basic techniques include:

1) Mouth to mouth breathing:

with the airway held open, pinch the nostrils closed, take a deep breath and seal your lips over he patients mouth. Blow steadily into the patients mouth watching the chest rise as if the patient was taking a deep breath.

2) Mouth to mask ventilation

3) Bag mask ventilation

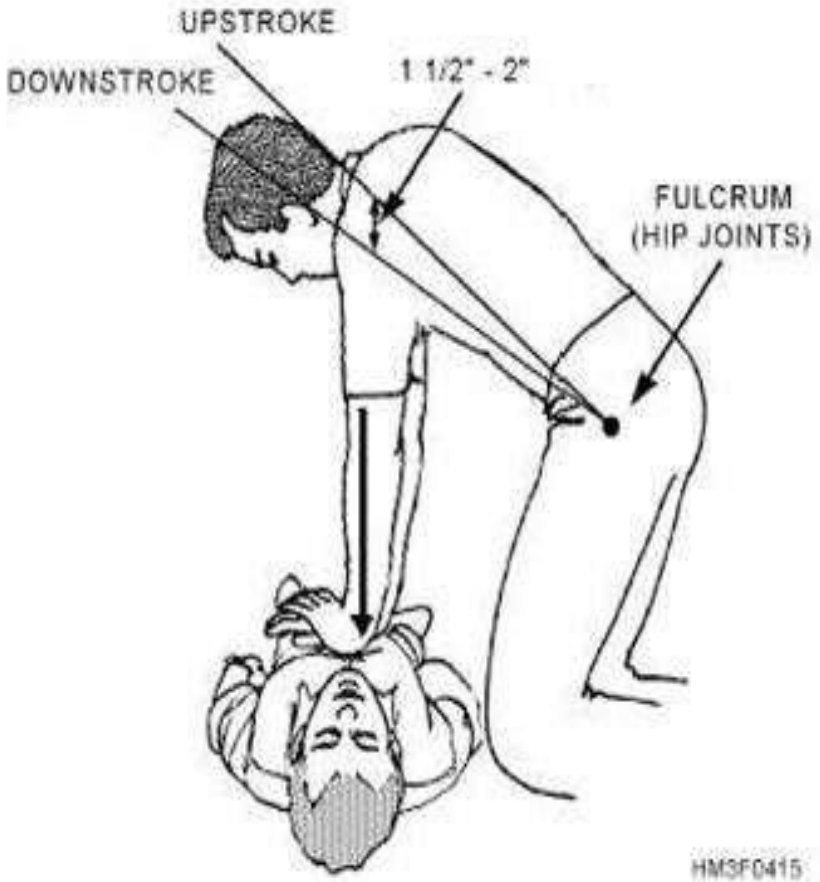
- In apneic adults with pulse give 1 rescue breath every 5-6 seconds or about 10-12 breaths per minute
- In apneic child or infant with pulse give 1 rescue breath every 2-3 seconds or about 20-30 breaths per minute

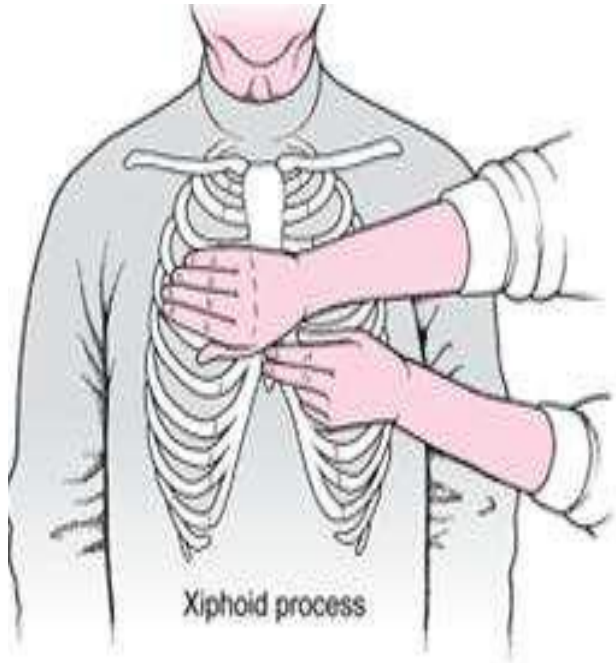
(C) Chest compressions (cardiac massage)

- The human brain cannot survive more than 3 minutes with lack of circulation. So chest compressions must be started immediately for any patient with absent central pulsations.

TECHNIQUE OF CHEST COMPRESSION

- Pt must be placed on a hard surface (wooden board).
- The palm of one hand is placed in the concavity of the lower half of the sternum 2 fingers above the xiphoid process. (AVOID xiphisternal junction → fracture & injury).
- The other **hand** is placed over the hand on the sternum.
- **Shoulders** should be positioned directly over the hands with the **elbows** locked straight and arms extended. Use your upper body weight to compress.
- Sternum must be depressed **at least 4-5 cm** in adults, and **2-4 cm** in children, **1-2 cm** in infants .


UPSTROKE
DOWNSTROKE
1 1/2" - 2"
FULCRUM
(HIP JOINTS)
HM3F0415


Xiphoid process

- Must be performed at a rate of **100/min**
- Equal compression : relaxation
- During CPR the ratio of chest compressions to ventilation should be as follows:

Single rescuer = **30:2**

In infants or children :-

One rescuer 30-2

Two resuers 15-2

- Chest compressions must be continued for 2 minutes before reassessment of cardiac rhythm.
  - ► (2 minutes = equivalent to 5 cycles 30:2).
- When possible change CPR operator every 2 min.

Chest compressions in infants (0-12 months)

PROBLEMS AND COMPLICATIONS OF CHEST COMPRESSIONS

1. RIB FRACTURES
2. FRACTURE STERNUM
3. RIB SEPARATION
4. PNEUMOTHORAX
5. HEMOTHORAX
6. LUNG CONTUSIONS
7. LIVER LACERATIONS
8. FAT EMBOLI
9. Vomiting , Aspiration

3) Assessment of restoration of breathing and circulation

- Contraction of pupil
- Improved color of the skin
- Free movement of the chest wall
- Swallowing attempts
- Struggling movements
- Return of or strong pulse

When to terminate BLS

- Pulse and respiration returns
- Emergency medical help arrive

ADULT
BASIC LIFE SUPPORT
(BLS)

OBJECTIVES

Students should be able to demonstrate:

- How to assess the collapsed victim
- How to perform chest compression and rescue breathing
- How to place an unconscious breathing victim in the recovery position.

BACKGROUND

- Approximately ***700,000*** cardiac arrests per year in Europe
- Survival to hospital discharge presently approximately ***5-10%***
- Bystander CPR vital intervention before arrival of emergency services – ***double or triple*** survival from SCA (sudden cardiac arrest)
- Early resuscitation and prompt defibrillation (within 1-2 minutes) can result in ***>60% survival***

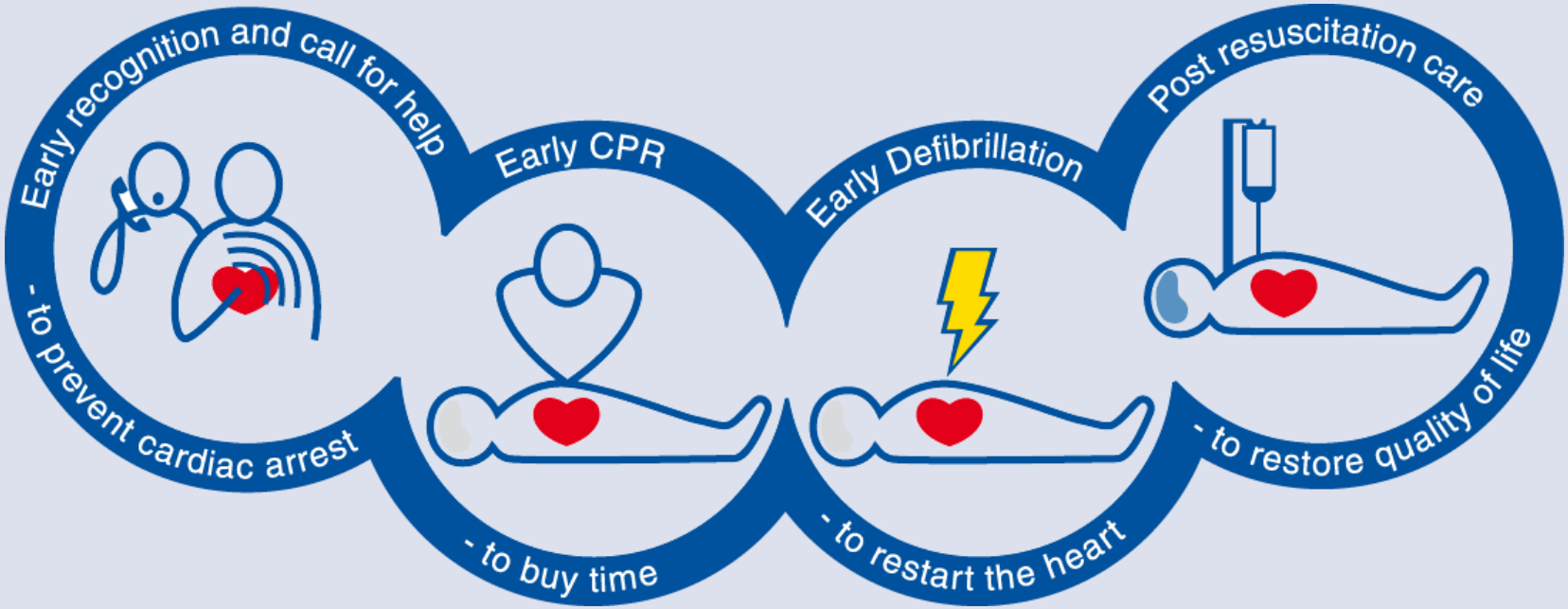
BASIC LIFE SUPPORT (BLS

Airway

Breathing

Circulation **(CAB)**

CHAIN OF SURVIVAL



BASIC LIFE SUPPORT

SEQUENCES OF PROCEDURES PERFORMED TO RESTORE THE CIRCULATION OF OXYGENATED BLOOD AFTER A SUDDEN PULMONARY AND/OR CARDIAC ARREST

CHEST COMPRESSIONS AND PULMONARY VENTILATION PERFORMED BY **ANYONE** WHO KNOWS HOW TO DO IT, **ANYWHERE, IMMEDIATELY, WITHOUT** ANY OTHER **EQUIPMENT**

Protective devices

Basic Life Support

Approach safely

Check response

Shout for help

Open airway

Check breathing

Call 997

30 chest compressions

2 rescue breaths

APPROACH SAFELY!

Scene

Rescuer

Victim

Bystanders

Approach safely

Check response

Shout for help

Open airway

Check breathing

Call 112

30 chest compressions

2 rescue breaths

CHECK RESPONSE

- Approach safely
- **Check response**
- Shout for help
- Open airway
- Check breathing
- Call 977
- 30 chest compressions
- 2 rescue breaths

CHECK RESPONSE

Shake shoulders gently

Ask “Are you all right?”

If he responds

- Leave as you find him.
- Find out what is wrong.
- Reassess regularly.

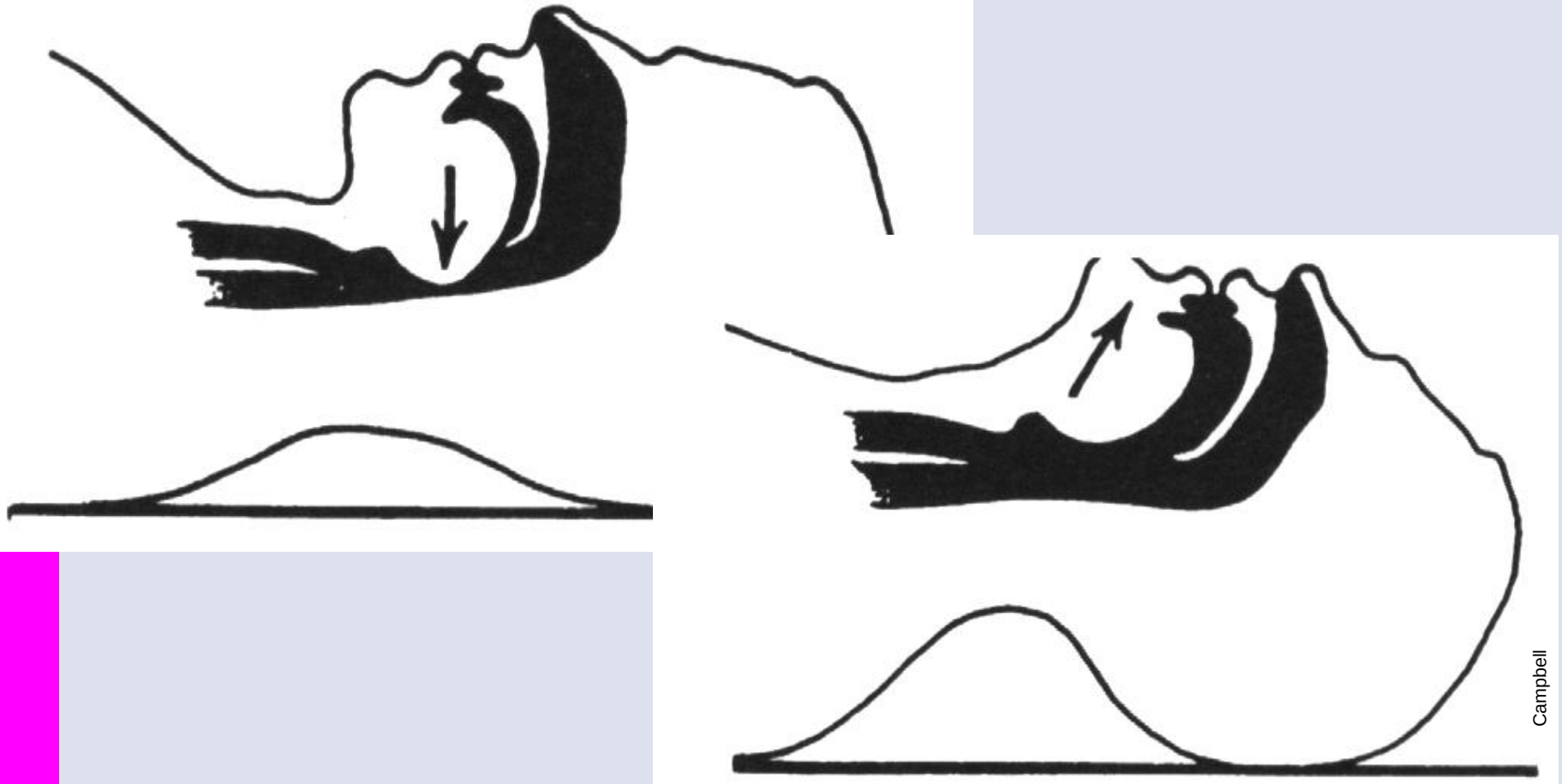
SHOUT FOR HELP

- Approach safely
- Check response
- **Shout for help**
- Open airway
- Check breathing
- Call 977
- 30 chest compressions
- 2 rescue breaths

OPEN AIRWAY

- Approach safely
- Check response
- Shout for help
- **Open airway**
- Check breathing
- Call 977
- 30 chest compressions
- 2 rescue breaths

AIRWAY OPENING BY NECK EXTENSION



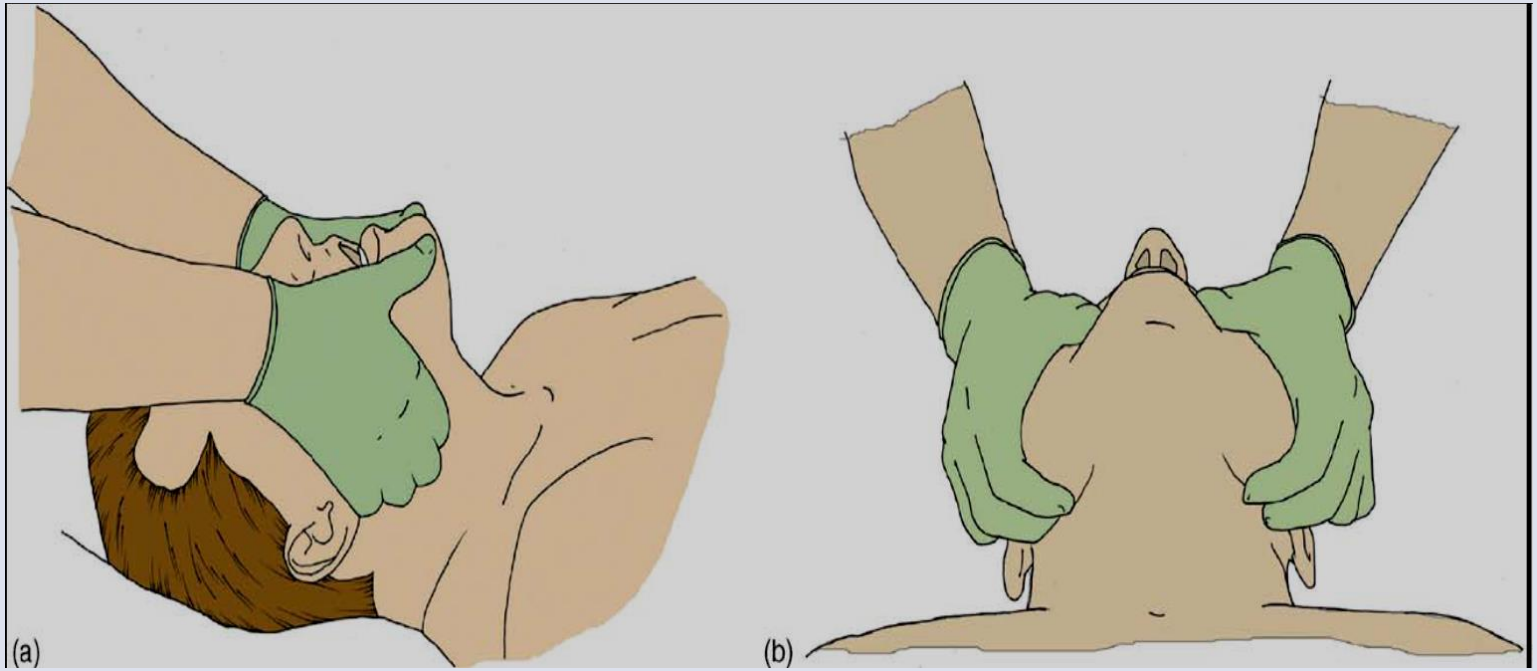
Campbell

OPEN AIRWAY

Head tilt and chin lift
- lay rescuers
- non-healthcare rescuers

No need for finger sweep
unless solid material can be seen in the airway

OPEN AIRWAY



Head tilt, chin lift + jaw thrust
- healthcare professionals

CHECK BREATHING

- Approach safely
- Check response
- Shout for help
- Open airway
- **Check breathing**
- Call 977
- 30 chest compressions
- 2 rescue breaths

CHECK BREATHING

- Look, listen and feel for NORMAL breathing
- Do not confuse agonal breathing with NORMAL breathing

AGONAL BREATHING

- Occurs shortly after the heart stops in up to 40% of cardiac arrests
- Described as barely, heavy, noisy or gasping breathing
- Recognise as a sign of cardiac arrest

Erroneous information can result in withholding CPR from cardiac arrest victim

POTENTIALLY REVERSIBLE CAUSES

(5 H's & 5 T's):

- **H**ypoxia
- **H**ypovolemia
- **H**ypothermia
- **H**yper/hypoK+and metabolic disorders
- **H+** ions (acidosis)

- **T**ension pneumothorax
- **T**amponade
- **T**oxic/therap. disturbances
- **T**hrombosis coronary
- **T**hrombosis pulmonary

Basic Life Support

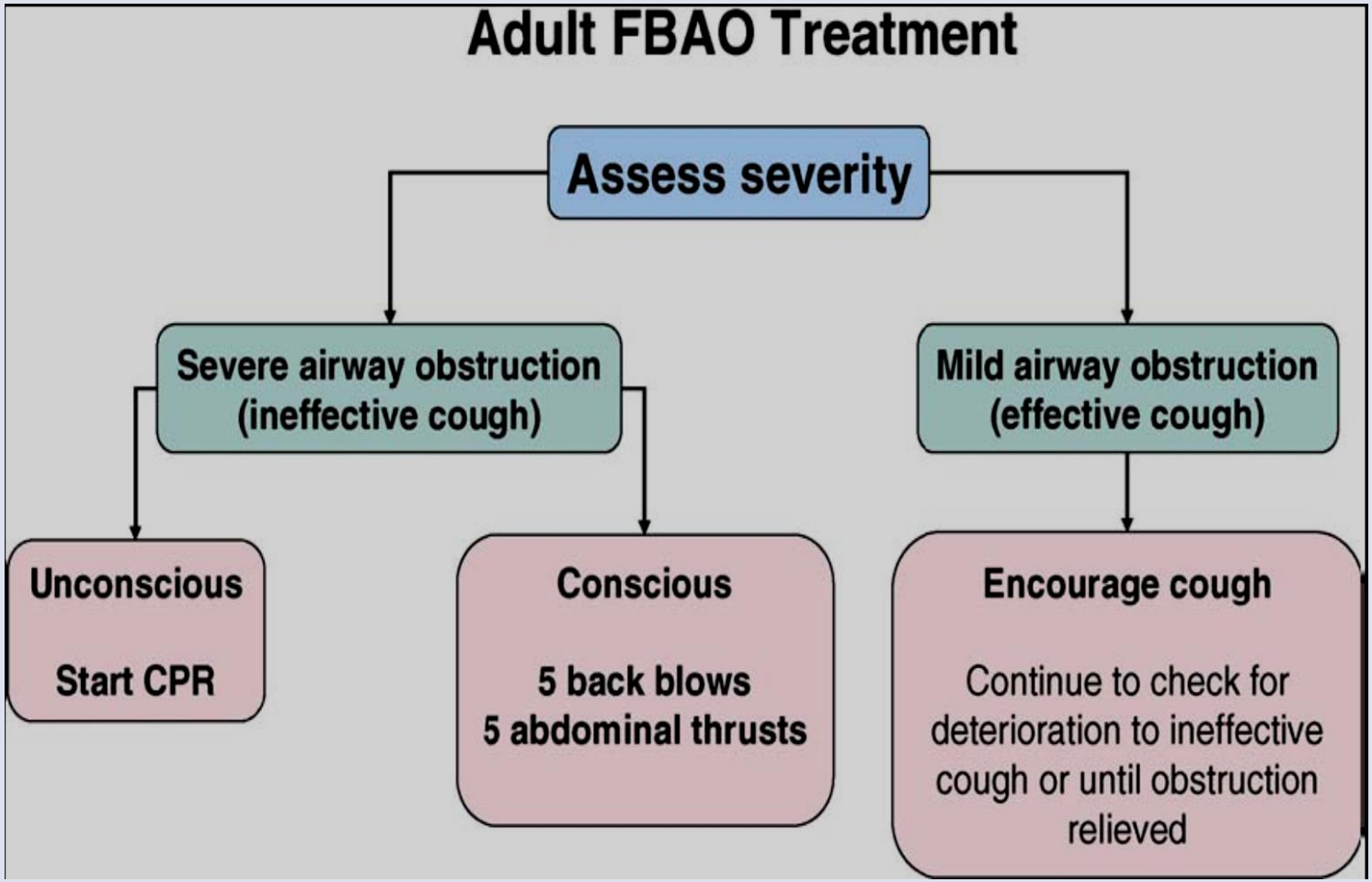
- Approach safely
- Check response
- Shout for help
- Open airway
- Check breathing
- **Call 977**
- 30 chest compressions
- 2 rescue breaths

FOREIGN-BODY AIRWAY OBSTRUCTION (FBAO)

Approximately 16 000 adults and children receive treatment for FBAO in the UK yearly

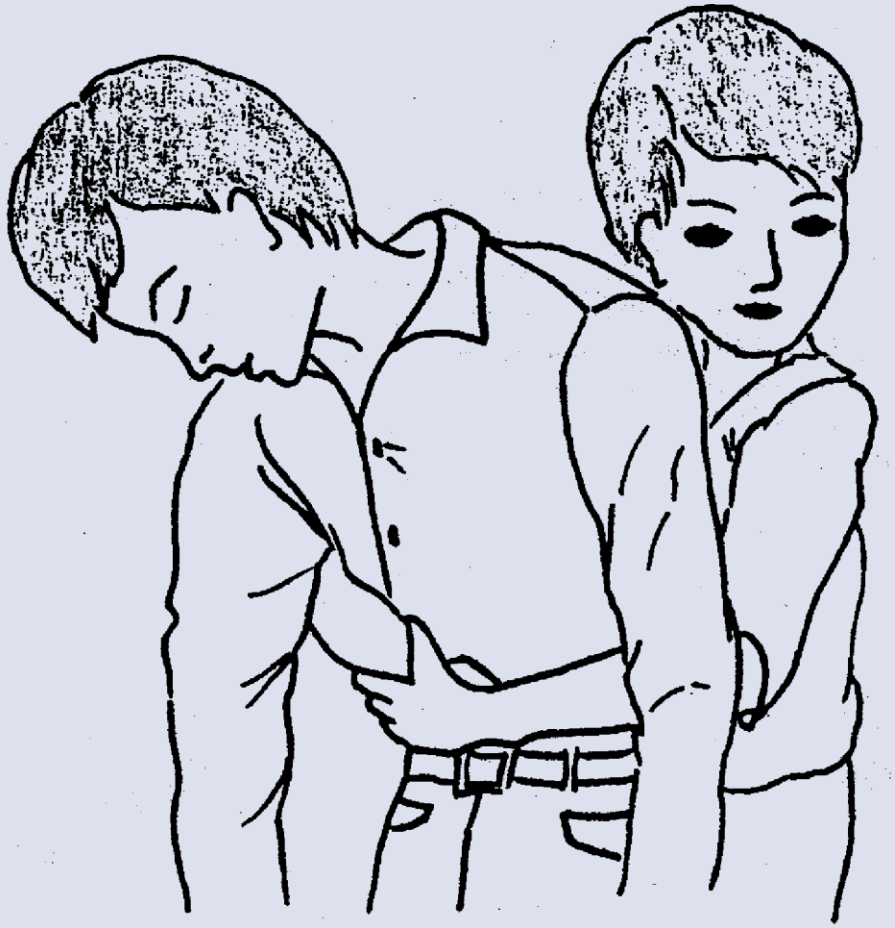
SIGNS	**MILD** obstruction	**SEVERE** obstruction
“Are you choking?”	“YES”	Unable to speak, may nod
Other signs	Can speak, cough, breathe	Can not breathe/wheezy breathing/silent attempts to cough/ unconsciousness

ADULT FBAO TREATMENT



BACK BLOWS

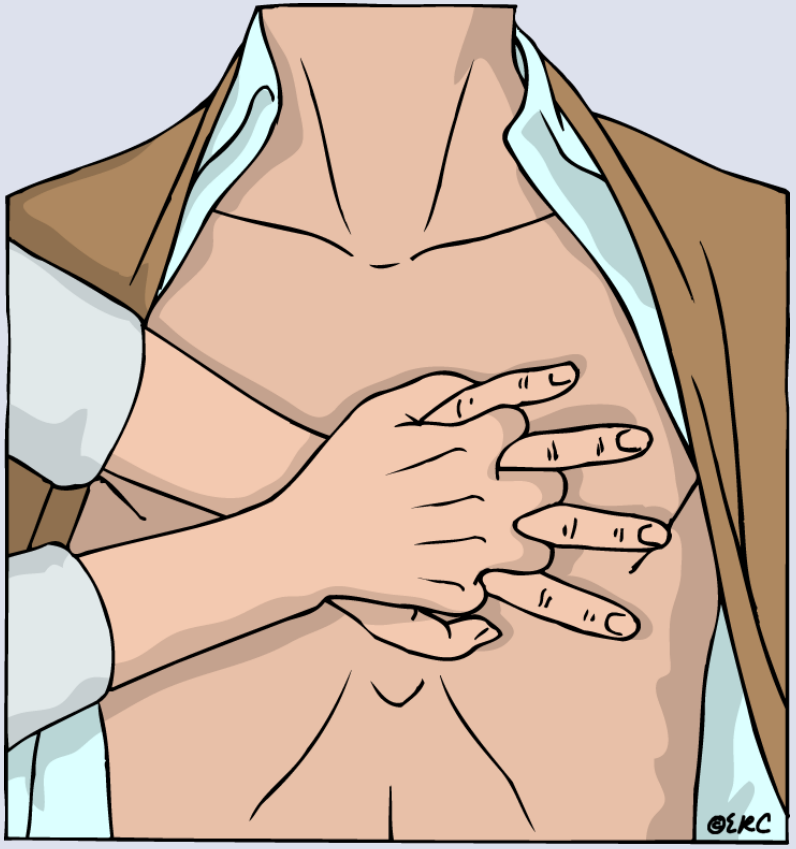
ABDOMINAL THRUSTS



30 CHEST COMPRESSIONS

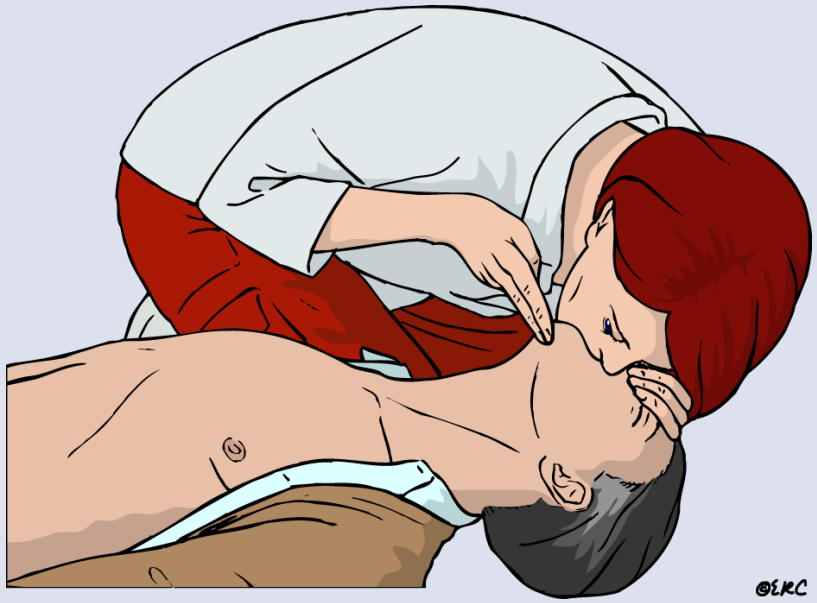
- Approach safely
- Check response
- Shout for help
- Open airway
- Check breathing
- Call 977
- **30 chest compressions**
- 2 rescue breaths

CHEST COMPRESSIONS



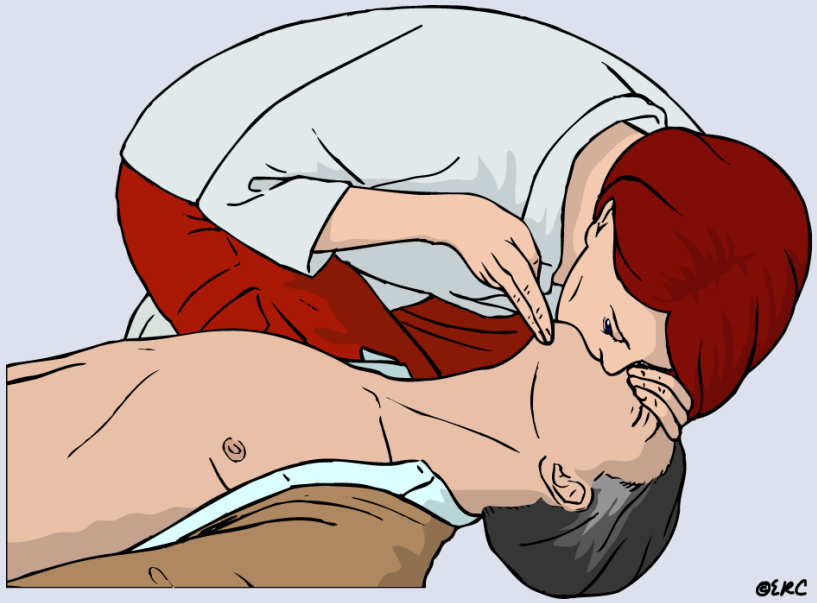
- Place the heel of one hand in the centre of the chest
- Place other hand on top
- Interlock fingers
- Compress the chest
  - Rate 100 min^{-1}
  - Depth 4-5 cm
  - Equal compression : relaxation
- When possible change CPR operator every 2 min

RESCUE BREATHS



- Approach safely
- Check response
- Shout for help
- Open airway
- Check breathing
- Call 977
- 30 chest compressions
- **2 rescue breaths**

RESCUE BREATHS



- Pinch the nose
- Take a normal breath
- Place lips over mouth
- Blow until the chest rises
- Take about 1 second
- Allow chest to fall
- Repeat

Breathing: Mouth To Nose (when to use)

- Can't open mouth
- Can't make a good seal
- Severely injured mouth
- Stomach distension

- Mouth to stoma (tracheotomy)

RESCUE BREATHS

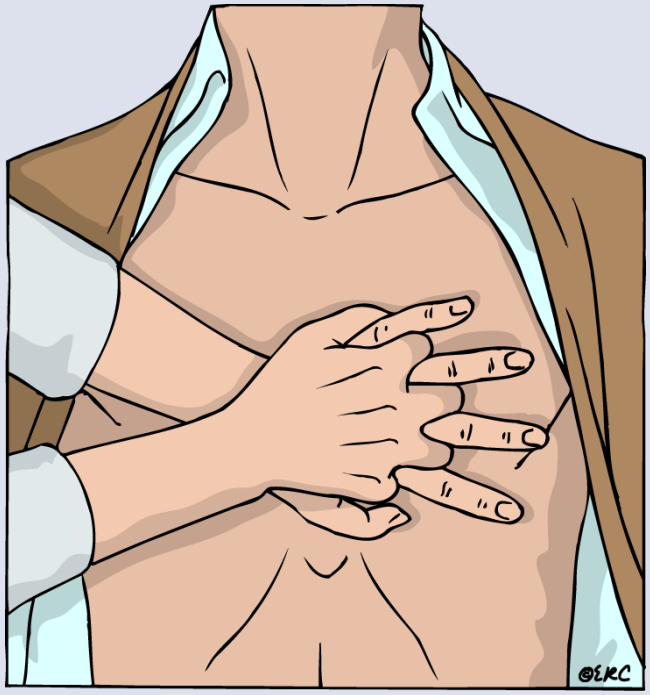
RECOMMENDATIONS:

- **Tidal volume**
  500 – 600 ml

- **Respiratory rate**
  give each breaths over about 1s with enough volume to make the victim's chest rise

- **Chest-compression-only**
  continuously at a rate of 100 min

CONTINUE CPR



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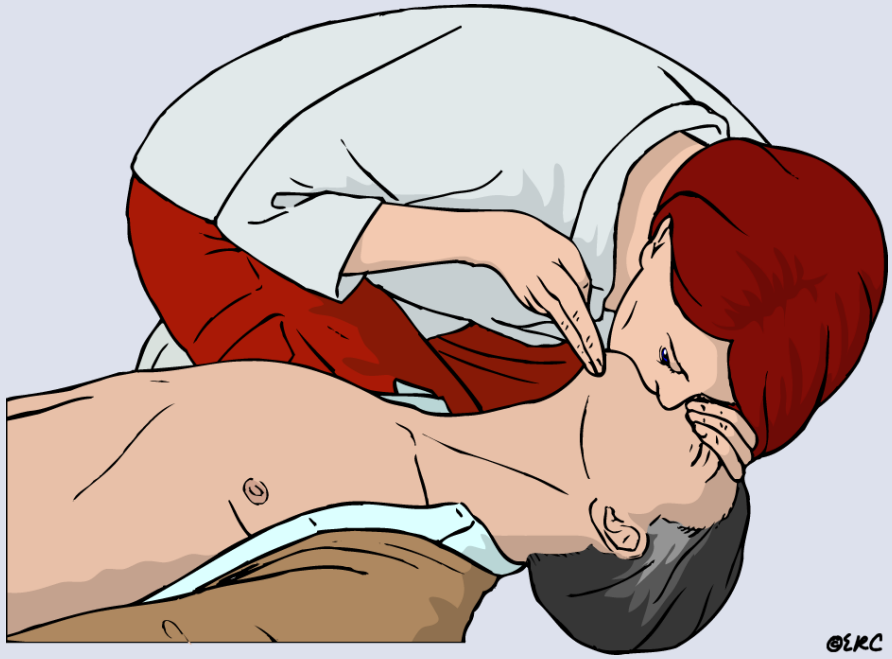

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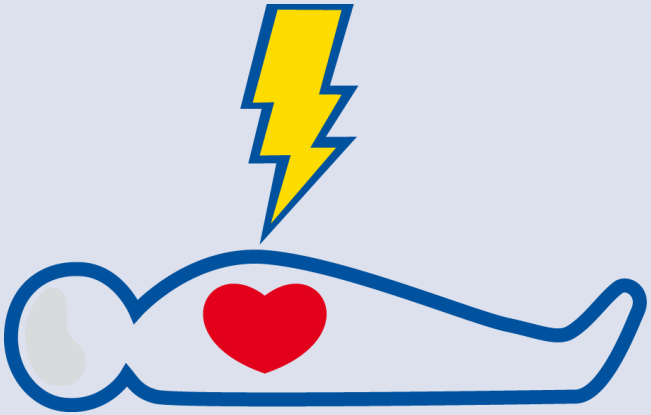
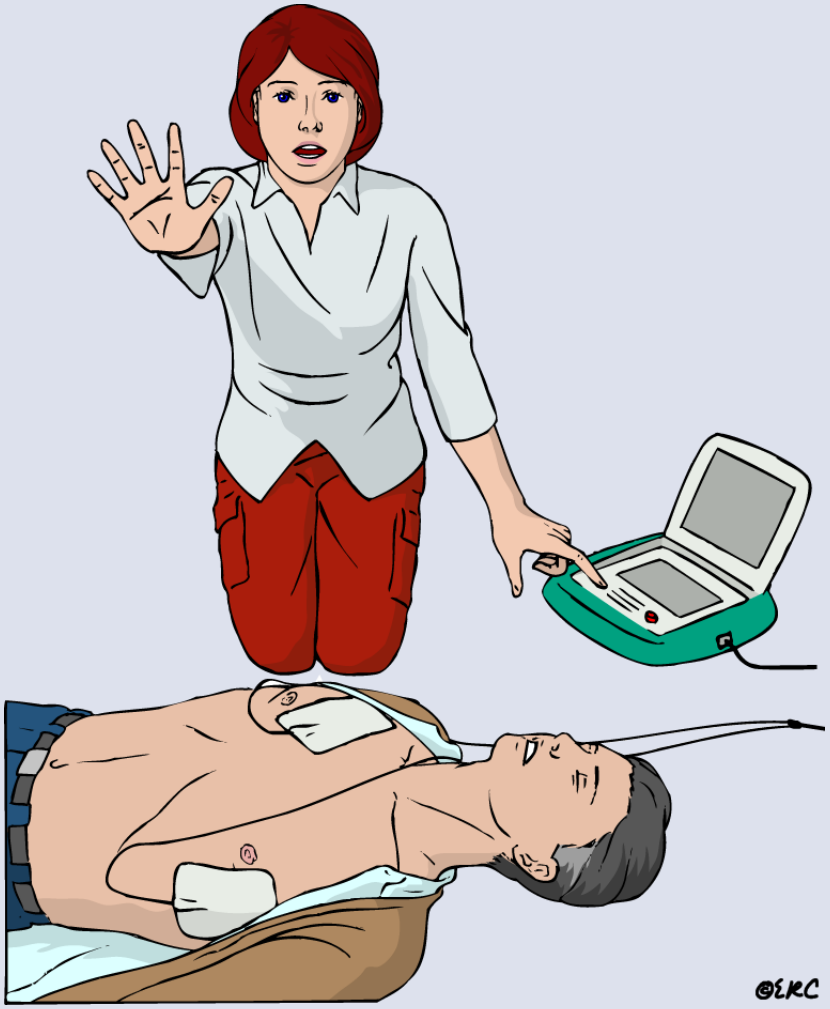
Basic Life Support

- Approach safely
- Check response
- Shout for help
- Open airway
- Check breathing
- Call 977
- 30 chest compressions
- 2 rescue breaths

DEFIBRILLATION





Approach safely

Check response

Shout for help

Open airway

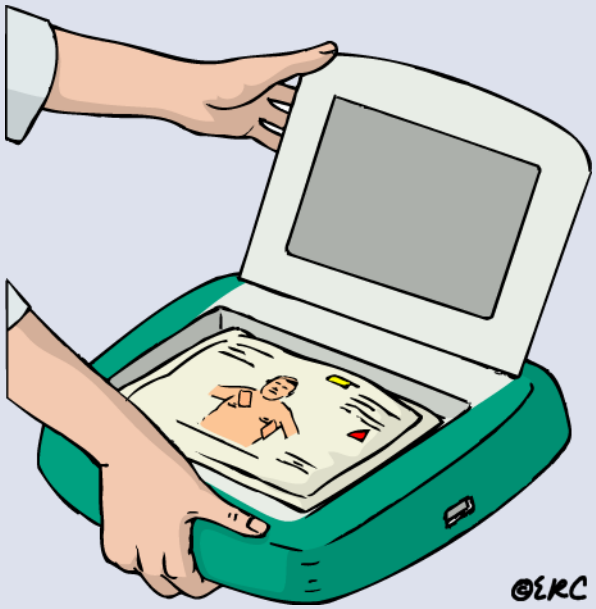
Check breathing

Call 977

Attach AED

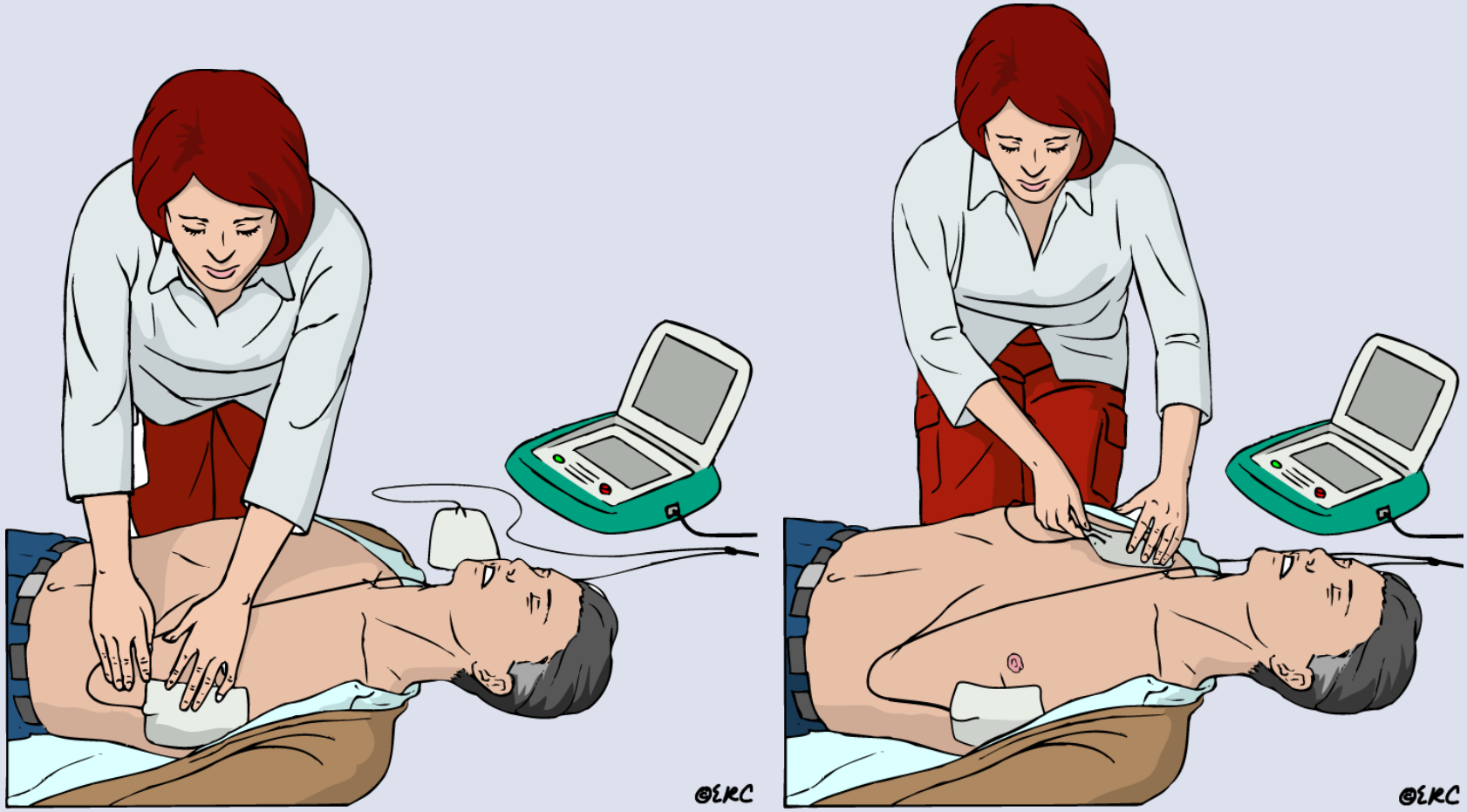
Follow voice prompts

AUTOMATED EXTERNAL DEFIBRILLATOR (AED)

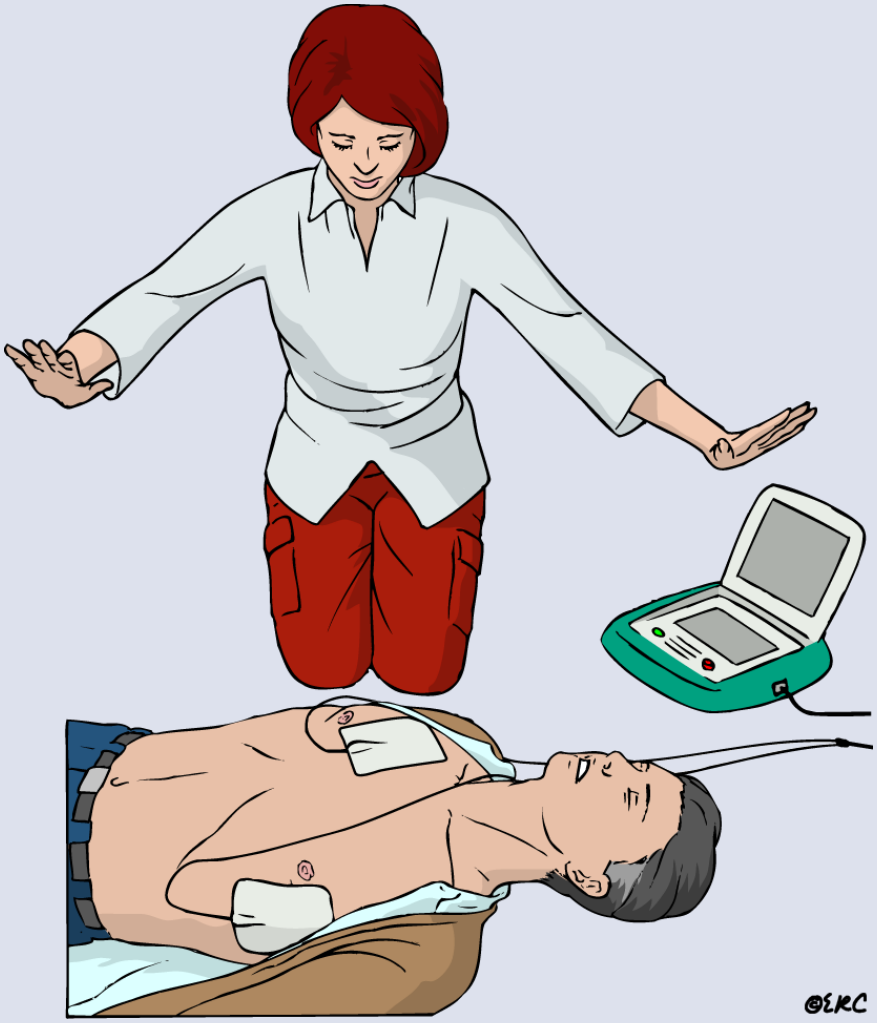


- Some AEDs will automatically switch themselves on when the lid is opened

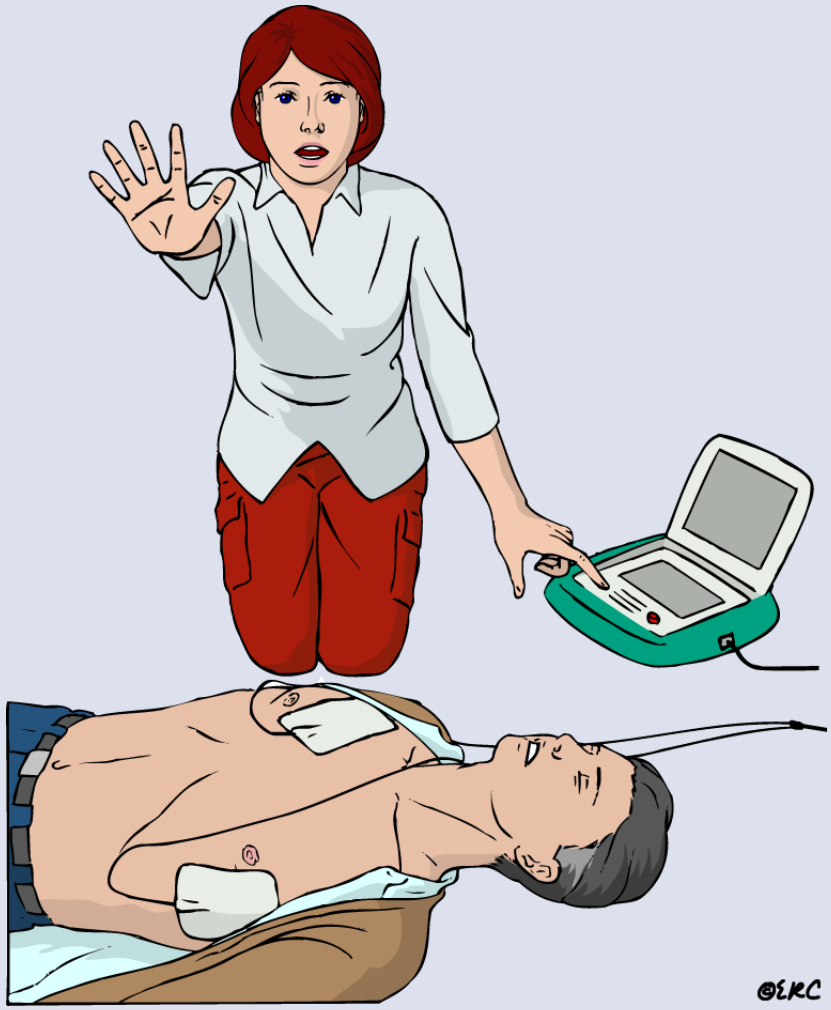
ATTACH PADS TO CASUALTY'S BARE CHEST



ANALYSING RHYTHM
DO NOT TOUCH VICTIM

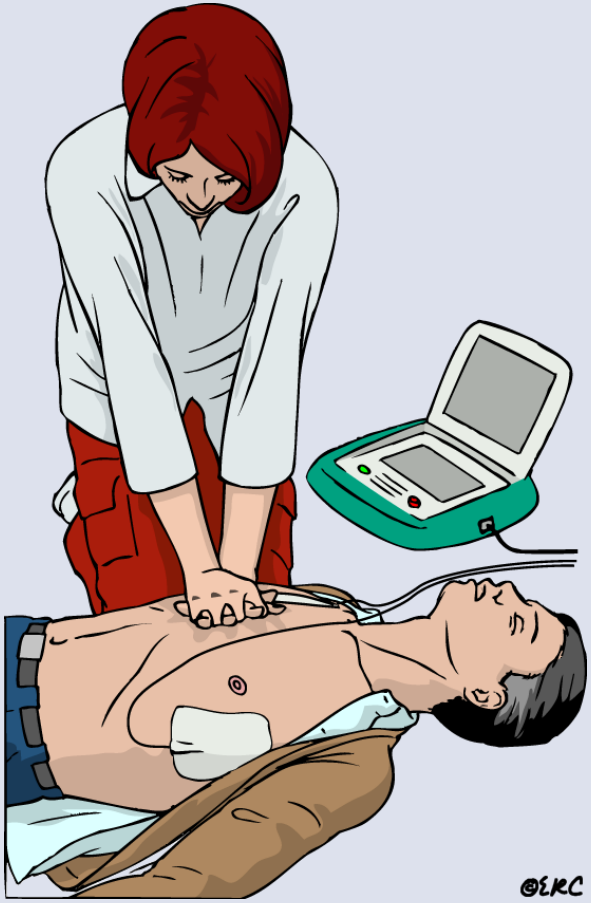


SHOCK INDICATED



- Stand clear
- Deliver shock

SHOCK DELIVERED
FOLLOW AED INSTRUCTIONS



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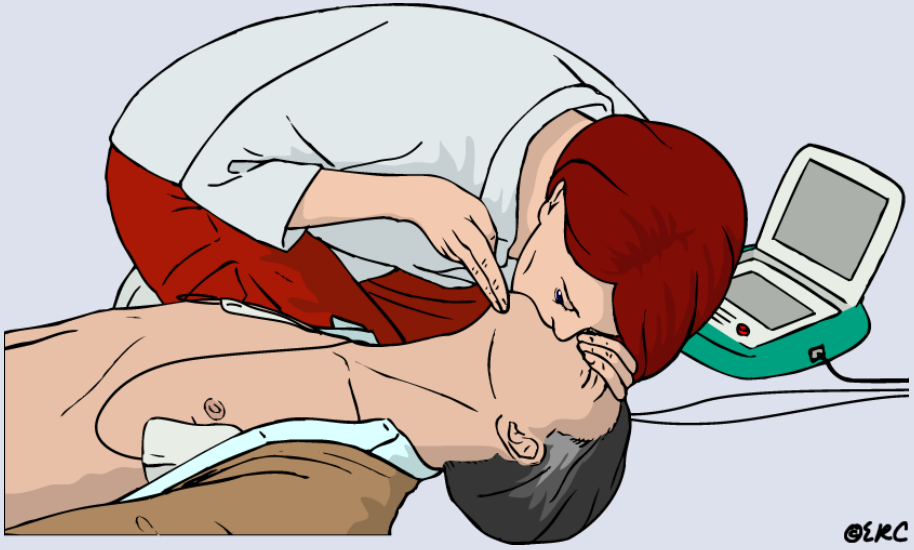

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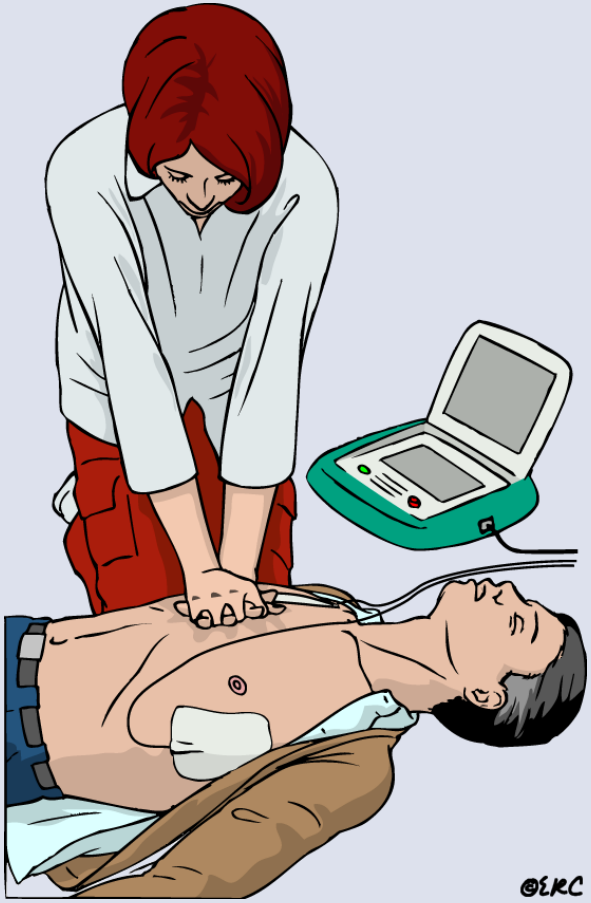
NO SHOCK ADVISED
FOLLOW AED INSTRUCTIONS



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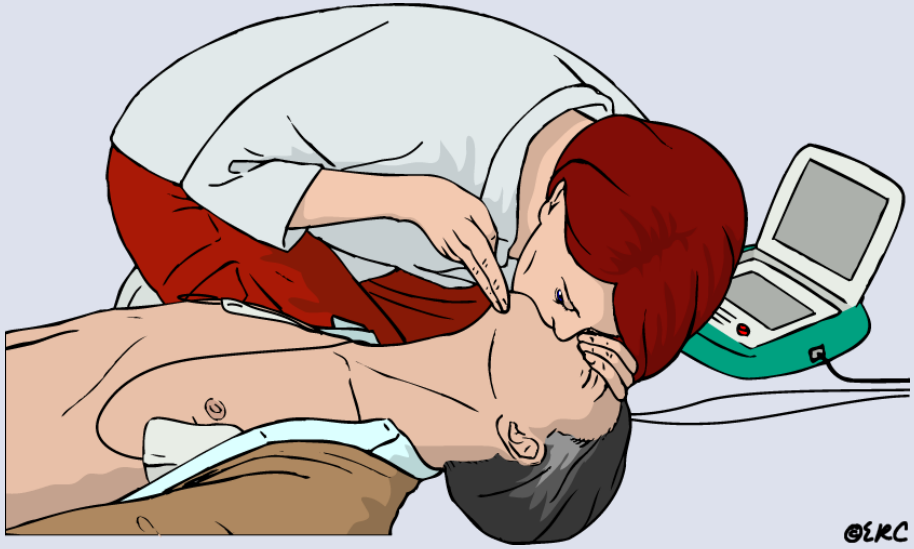

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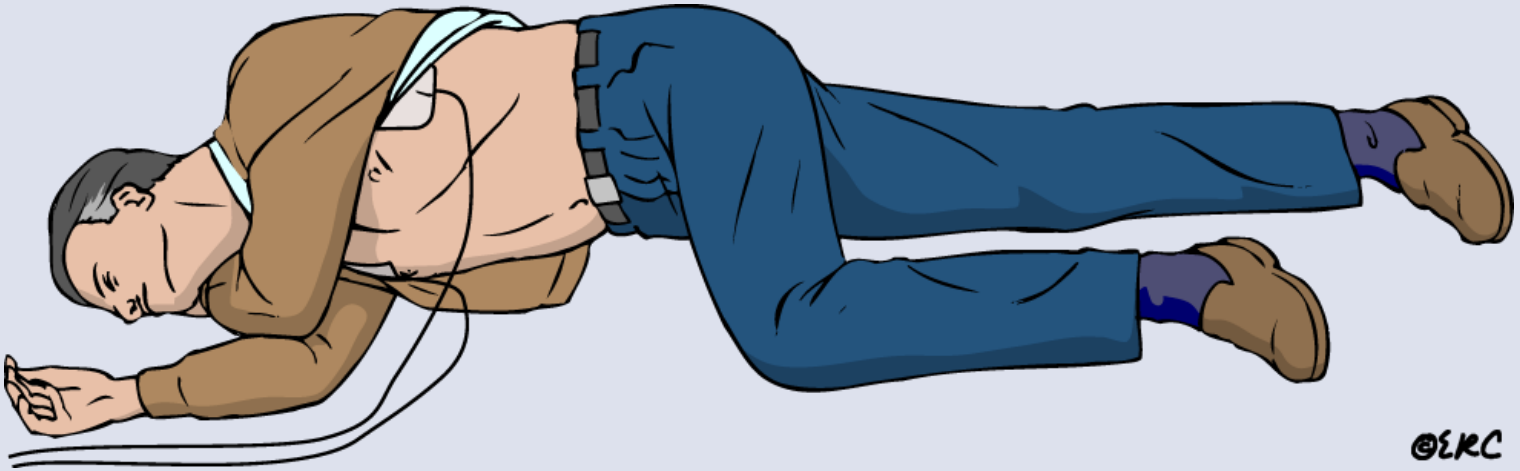
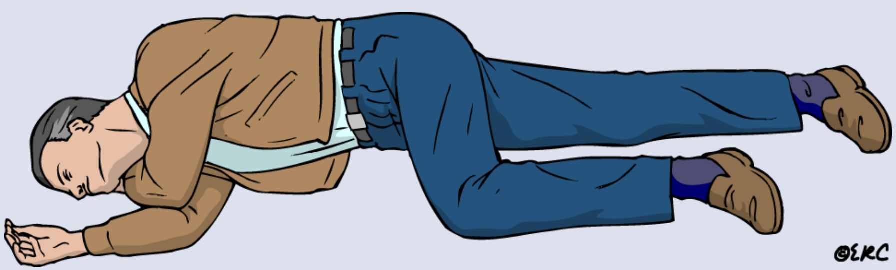
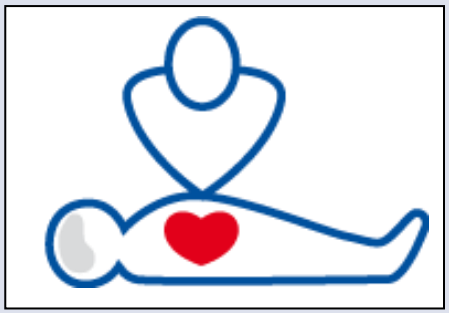
IF VICTIM STARTS TO BREATHE NORMALLY PLACE IN RECOVERY POSITION

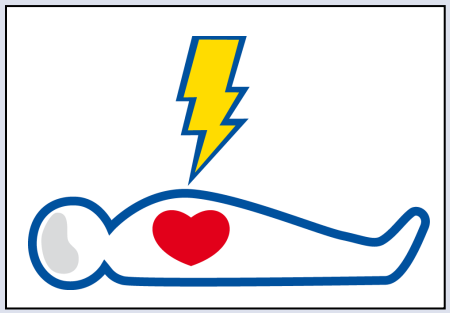


Basic Life Support





Approach safely
Check response
Shout for help
Open airway
Check breathing
Call Emergency System
30 chest compressions
2 rescue breaths



Approach safely
Check response
Shout for help
Open airway
Check breathing
Call Emergency System
Attach AED
Follow voice prompts

CONTINUE RESUSCITATION UNTIL

- Qualified help arrives and takes over
- The victim starts breathing normally
- Rescuer becomes exhausted

When Can I Stop CPR?

- Victim revives
- Trained help arrives
- Too exhausted to continue
- Unsafe scene
- Physician directed (do not resuscitate orders)
- Cardiac arrest of longer than 30 minutes
  - (controversial)

Why CPR May Fail

- **Delay in starting**
- **Improper procedures (ex. Forget to pinch nose)**
- **No ACLS follow-up and delay in defibrillation**
  - Only 15% who receive CPR live to go home
  - Improper techniques
- **Terminal disease or unmanageable disease (massive heart attack)**

Injuries Related to CPR

- **Rib fractures**
- **Laceration related to the tip of the sternum**
  - **Liver, lung, spleen**

Complications of CPR

- Vomiting
- Aspiration
- Place victim on left side
- Wipe vomit from mouth with fingers wrapped in a cloth
- Reposition and resume CPR

REPETITION

1. Name adult basic life support sequences of actions.
2. What is the manoeuvre for keeping the airway open called?
3. What is the numeral combination of chest compression and rescue breaths in adult basic life support?
4. Where do you place your hands while performing chest compressions?
5. How would you describe „agonal breathing“?
6. What is the telephone number of emergency response system?
7. Name 2 techniques applied in severe airway obstruction?

THANK YOU

ARTERIAL BLOOD GAS

Acid-Base Balance

- Cells need steady balance between acids and bases
- Normal acid base balance: [1:20] One part acid (CO_2): 20 parts base (HCO_3^-) = perfect pH of (7.35 – 7.45)
- Consider CO_2 an acid b/c it results in an acid when dissolved in blood:

  $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow HCO_3^- + H^+$
- Acid gain or base loss => Acidosis (pH < 7.35)
- Gain base or lose acids => Alkalosis (ph > 7.45)

Regulation of Acid-Base Balance

- Regulatory mechanisms are very sensitive to small changes in pH:

1. Buffers
2. Respiratory System
3. Renal System

Buffers

- Immediately combine with excess acid to form substances that do not greatly affect pH.
- Bicarbonate (HCO_3^-) Most important buffer ,
  Absorption, excretion,production regulated by kidney.
- Other buffers: Phosphate, Ammonium, Protein

Respiratory System

- If acidotic :

Hyperventilation => CO_2 eliminated => improvement in acidotic state .

- If alkalotic :

hypoventilation => CO_2 retained => improvement in alkalotic state.

- Quick response: within 1-2 min of pH imbalance.

Renal System

- Kidneys conserve or eliminate H+ and HCO3- in response to abnormal pH.
- If acidotic =>

Eliminate H+ (acid) and retain HCO3- (base) in effort to normalize pH.

- If alkalotic =>

Eliminate HCO3- (base) in effort to normalize pH.

- Response to abnormal pH is slow (hours to days).

Acid Base Imbalances

Respiratory Acidosis

- Acidosis is due to hypoventilation
- Causes:
  - COPD (Emphysema, bronchitis)
  - failure of respiratory muscles (ALS, Guillain-Barre)
  - airway obstruction (e.g., post-op)
- Metabolic compensation: Kidneys excrete H+/retain HCO3- .

Respiratory Alkalosis

- Alkalosis is due to hyperventilation.

- Causes
  - anxiety (Rx with paper bag)
  - pneumonia
  - pulmonary edema

- Metabolic compensation: Kidneys excrete HCO_3^- (if problem lasts hours/days)

Metabolic Acidosis

- Acidosis is due increase in metabolic acids and/or loss of HCO_3^-
- Increased acids due to
  - diabetic ketoacidosis
  - renal failure (kidneys cannot excrete H+)
  - poisoning .
- Lost alkali (base) due to:
  - severe diarrhea
  - intestinal malabsorption
- Respiratory compensation: hyperventilation to blow off CO_2.

Metabolic Alkalosis

- Alkalosis is due to loss of acid/H+ or excess alkali intake.
  - Vomiting
  - gastric suction
  - diuretics

- Respiratory compensation: hypoventilation to retain CO2.

ABG Parameters

- ***PaO_2***
  - Partial pressure of O_2
  - Normal: 80 - 100 mmHg
  - Measures the effectiveness of the lungs in oxygenating the blood. Reflects ability of lungs to diffuse inspired oxygen across the alveolar membrane into the circulating blood

- ***SaO2***
  - Oxygen saturation
  - % of hgb that is saturated with oxygen.
  - Normal: > 95%

- ***$PaCO_2$***
  - Partial Pressure of CO_2
  - Normal: 35 - 45 mmHg
  - Reflects effectiveness of ventilation (movement of air into and out of lungs).

- ***HCO_3^-***
  - Bicarbonate ion; metabolic parameter.
  - Part of buffer system.
  - **Normal: 22 - 26 mEq/l**

- ***pH –***

Measures acidity.

Determined by relative concentrations of CO_2 and HCO_3 .

Normal (7.35 - 7.45)

DEFINITION of ABG

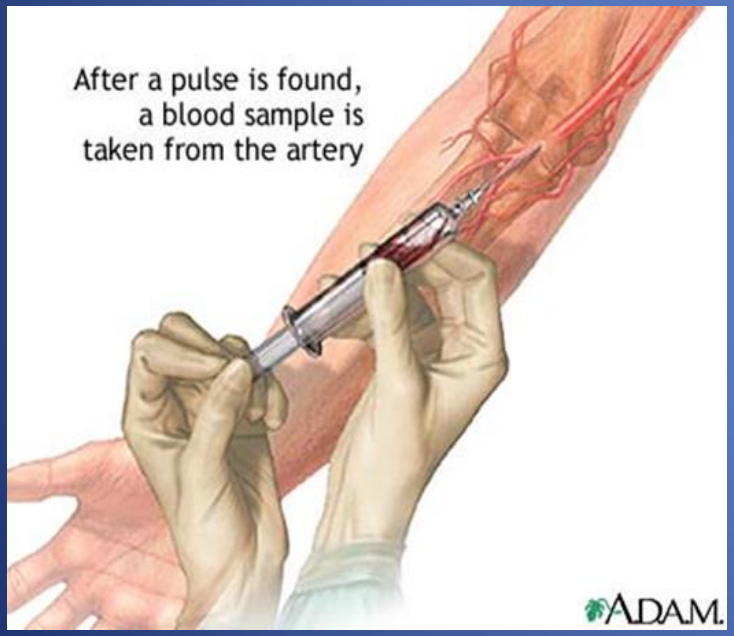
- It is a diagnostic procedure in which a blood is obtained from an artery directly by an arterial puncture or by arterial catheter.

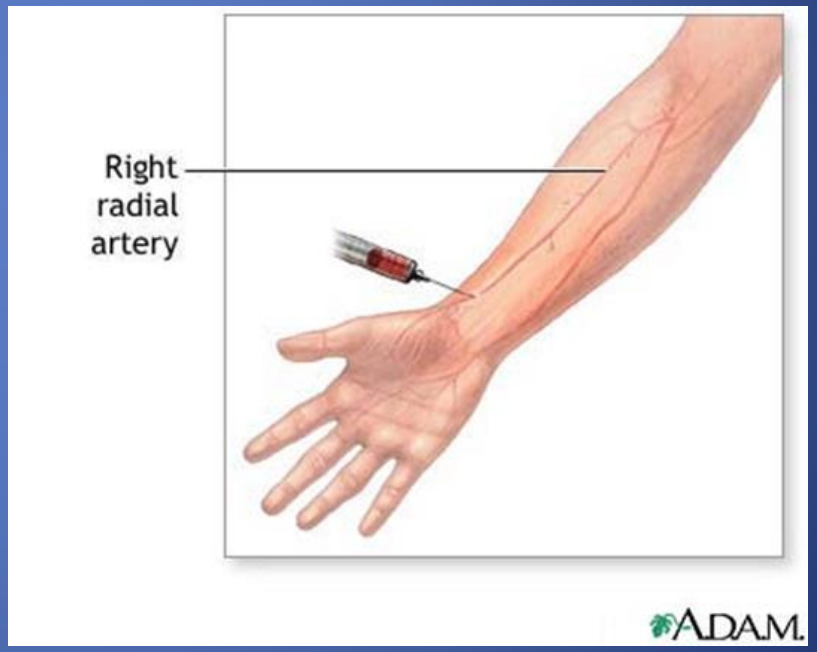
Sites for obtaining ABG

1. Radial artery (most common)
2. Brachial artery
3. Femoral artery

Radial is the most preferable site used because:

- It is easy to access
- It is not a deep artery which facilitate palpation, stabilization and puncturing
- The artery has a collateral blood circulation


After a pulse is found,
a blood sample is
taken from the artery
A.D.A.M.


Right
radial
artery
A.D.A.M.

indication

1. To obtain information about patient ventilation (PCO2) , oxygenation (PO2) and acid base balance.
2. Monitor gas exchange and acid base abnormalities for patient on mechanical ventilator.
3. To evaluate response to clinical intervention and diagnostic evaluation (oxygen therapy)

Contraindications

1. Bleeding diathesis
2. AV fistula
3. Severe peripheral vascular disease, absence of an arterial pulse
4. Infection over site

Normal values:

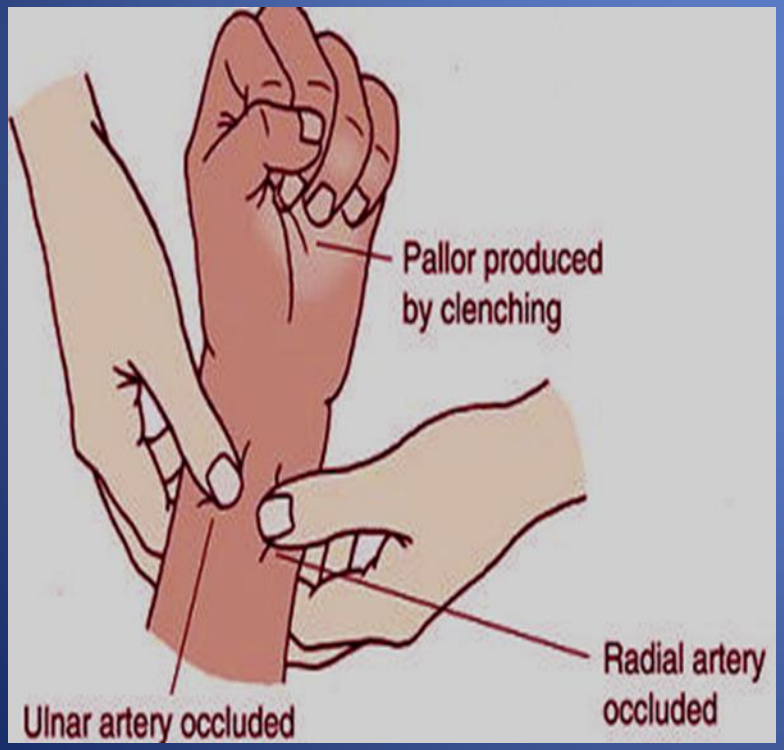
- ***PH*** = 7.35 – 7.45
- ***PCO2*** = 35 – 45 mmhg
- ***PO2*** = 80 – 100 mmhg
- ***HCO3*** = 22 – 28 meq/L

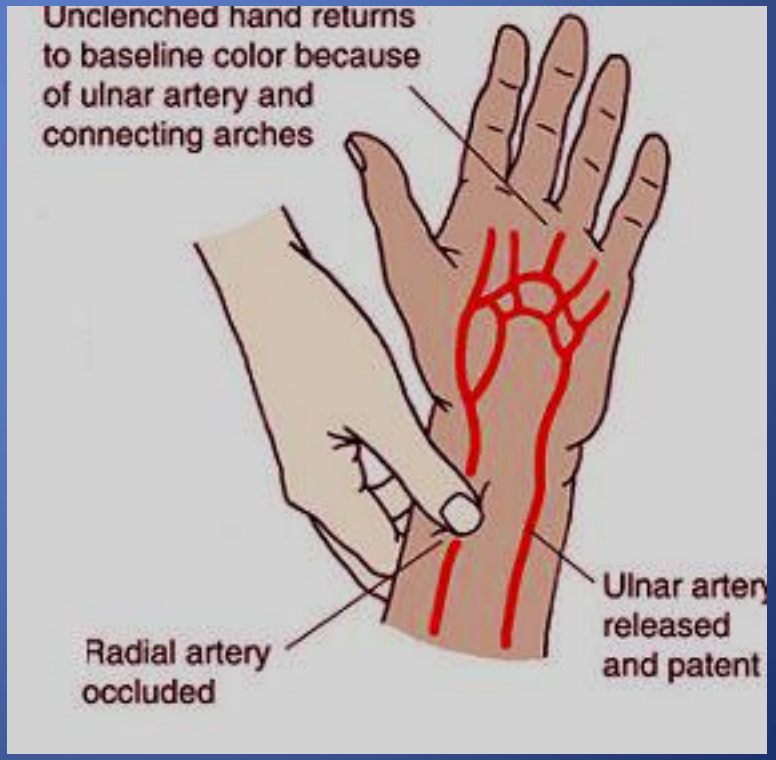
Preparatory phase:

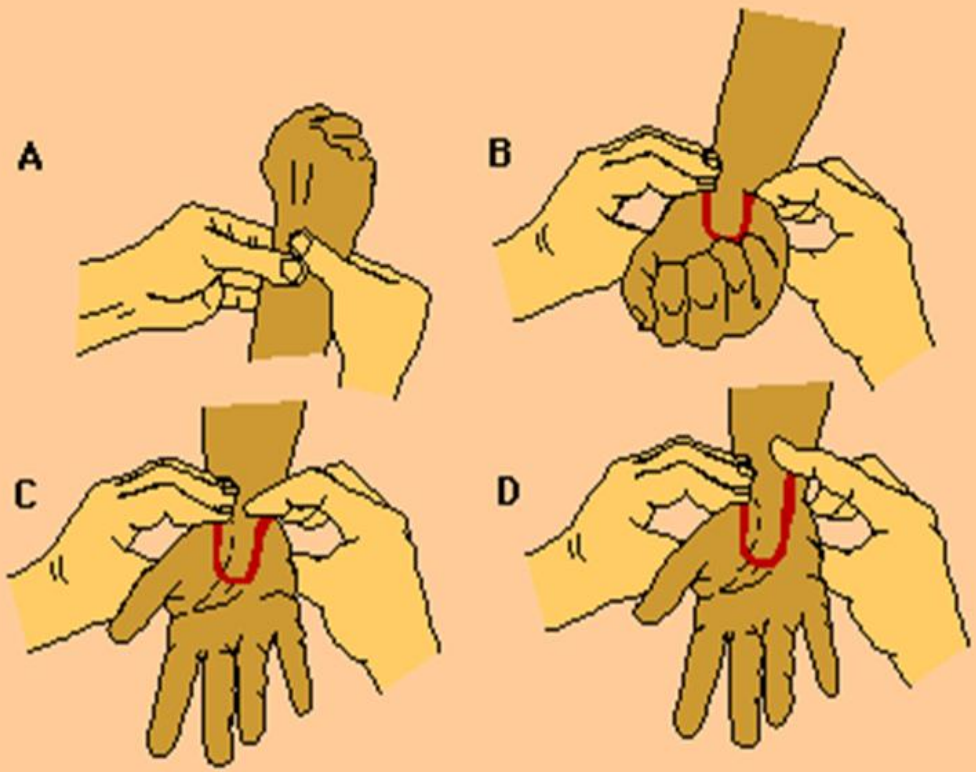
- Record patient inspired oxygen concentration.
- Check patient temperature
- Explain the procedure to the patient .
- If not using hepranized syringe , hepranize the needle.
- Perform Allen's test.

- *<u>Allen's test</u>*

It is a test done to determine that collateral circulation is present from the ulnar artery in case thrombosis occur in the radial







Modified Allen's test The patient's hand is initially held high while the fist is clenched and both radial and ulnar arteries are compressed (A); this allows the blood to drain from the hand. The hand is then lowered (B) and the fist is opened (C). After pressure is released over the ulnar artery (D), color should return to the hand within six seconds, indicating a patent ulnar artery and an intact superficial palmar arch. (Redrawn from American Heart Association. Textbook of Advanced Cardiac Life Support, 1994.)

Performance phase:

- Wash hands
- Put on gloves
- Clean with alcohol swab
- Palpate the artery for maximum pulsation
- If radial, perform Allen's test
- Skin and subcutaneous tissue may be infiltrated with local anesthetic agent if needed

- Insert needle at 45 radial ,60 brachial and 90 femoral.
- Withdraw the needle.
- Check bubbles in syringe.
- Place the capped syringe in the container of ice immediately .
- Maintain firm pressure on the puncture site for 5 minutes, if patient has coagulation abnormalities apply pressure for 10 – 15 minutes.

Follow up phase:

- Palpate the pulse distal to the puncture site.
- Assess for cold hands, numbness, tingling or discoloration.
- Documentation include:

results of Allen's test, time the sample was drawn, temperature, puncture site, time pressure was applied and if O2 therapy is there.

complication

1. Arteriospasm
2. Distal ischemia

3. Hematoma
4. Hemorrhag

5. Infection
6. Numbness

ABG Interpretation:

Step 1 (Assess Oxgenation)

- Look at PaO_2 and SaO_2
  - Normal
  - Hypoxemic

Step 2 (Assess Acid-Base Balance)

- Look at pH
  - Acidotic, alkalotic, or normal?
  - If normal
    - High normal?
    - Low normal?

Step 3

- Look at $PaCO_2$
  - Is it altered (i.e. increased or decreased)?
  - If altered, consider the direction of the alteration:
    - Could it have ***caused*** the alteration in pH?
    - Could it be compensation?

Step 4

- Look at HCO_3^-
  - Is it altered (i.e. increased or decreased)?
  - If altered, consider the direction of the alteration:
    - Could it have ***caused*** the alteration in pH?
    - Could it be compensation?

Step 5

- Decide if the abnormal pH is caused by the pCO2 (respiratory causes) or the HCO3 (metabolic causes) or mixed.

Mechanical ventilation

objectives

- **To define what is the mechanical ventilator.**
- **To know what are the indications for M.V .**
- **To determine modes of mechanical ventilation .**
- **To know how to adjust M.V .**
- **To know how to deal with complications of M.V .**
- **To determine what is the nursing management of ventilated patient .**

- **What is Mechanical Ventilation?**
- Mechanical Ventilation is a form of therapy that is used on patients who are unable to breathe on their own.
- A certain level of ventilation is required in order to maintain the proper levels of oxygen and carbon dioxide in the body. This process is referred to as Gas Exchange.
- **A Mechanical Ventilator** is a device that is used to provide positive pressure ventilation in order to help normalize a patient's arterial blood gas levels to maintain an adequate acid-base balance.


MAQUET
MAQUET
SERVO-s


A/C
PC
12
20
1.00
3.0
50
50
PEEP
5.0

What are the Types of Mechanical Ventilation?

- In general, when someone mentions Mechanical Ventilation, they are usually referring to conventional positive pressure ventilation.
- Here are examples of all types of Mechanical Ventilation:
- • Positive pressure ventilation
- • Negative pressure ventilation, negative pressure is applied to abdomen and thorax to draw air into lungs .
- • Invasive mechanical ventilation
- • Noninvasive mechanical ventilation

Spontaneous respiration vs. Mechanical ventilation

- **Natural Breathing**
  - **Negative inspiratory force**
  - **Air pulled into lungs**
- **Mechanical Ventilation**
  - **Positive inspiratory pressure**
  - **Air pushed into lungs**

Benefits of Mechanical Ventilation

There are many benefits for patients who are receiving Mechanical Ventilation. These include the following:

- It helps decrease the patient's work of breathing which helps the respiratory muscles rest and recover.
- It helps the patient get adequate amounts of oxygen.
- It provides stability and allows medications to work while the patient heals.
- It helps the patient achieve adequate ventilation by removing carbon dioxide for effective gas exchange

Indications for Mechanical Ventilation

In general, Mechanical Ventilation is indicated whenever a patient's spontaneous breathing is not adequate enough to sustain life.

The following are examples of conditions in which ventilatory support is needed:

- **Insufficient Oxygenation**
- Inadequate oxygenation, which is known as hypoxemia, can impact the functionality of tissues and vital organs in the body if left untreated. Mechanical Ventilation helps treat hypoxemia by providing a sufficient amount of oxygen into the lungs so that it can be distributed throughout the body.
- **Insufficient Ventilation**
- Healthy lungs work to remove carbon dioxide from the body.
- Mechanical ventilatory support is indicated if the patient has inadequate ventilation by the lungs. It's common in conditions with apnea, chronic respiratory acidosis, such as COPD, and neuromuscular disorders.

- **Acute Lung Injury**
- An acute injury to the lungs that occurs from an event such as sepsis, pneumonia, aspiration, or trauma.
- **Severe Asthma**
- Mechanical Ventilation may be indicated in patients who are experiencing a severe asthma attack that requires intubation.
- **Severe Hypotension**
- Mechanical Ventilation may be indicated in severe episodes of low blood pressure, such as with shock, sepsis, and Congestive Heart Failure (CHF).
- **Inability to Protect the Airway**
- An unconscious patient with breathing difficulties may be at an increased risk for aspiration. Aspiration occurs when the patient accidentally inhales nasal and oral secretions directly into the lungs. Establishing a patent airway and maintaining spontaneous breathing via Mechanical Ventilation can help prevent this from occurring.

Modes of Ventilation:

Primary Control Variables:

In mechanical ventilation, there are two primary control variables:
1. Volume Control
2. Pressure Control

Volume Control

Volume Control means that you can set (or control) the patient's tidal volume. So with a set tidal volume and a set respiratory rate, this means that there is a known minute ventilation. This is good when it comes to making adjustments to achieve a desired $PaCO_2$.

One of the negative aspects of using Volume Control is that, since the tidal volume is preset, if the patients lung compliance were to decrease, this could result in high peak pressures.

Another drawback of Volume Control is patient-ventilator dyssynchrony.

Pressure Control

Pressure Control means that you can set (or control) the patient's pressure in order to achieve a desired tidal volume.
As with Volume Control, a Pressure-Controlled tidal volume and set rate can help you reach a desired $PaCO_2$.
The main disadvantage of using Pressure Control is the patient's tidal volume can potentially be unstable if there are changes in the patient's lung compliance or airway resistance.
So again, Volume Control and Pressure Control — those are the two control variables.
When initiating mechanical ventilation on a patient, once you
select the control variable, now you can choose the actual
operational mode that determines the pattern of breathing for the patient.

Primary Ventilator Modes

- **Assist/Control (A/C) Mode**
- In this mode, a minimum number of preset mandatory breaths are delivered by the ventilator but the patient can also trigger assisted breaths. The patient makes an effort to breathe and the ventilator assists in delivering the breath.
- With that said, this mode of ventilation does not allow the patient to take spontaneous breaths. In this mode, **the operator can set either a controlled pressure or a controlled volume.**
- The sensitivity control can be adjusted to make it easier or harder for the patient to initiate a breath.

- **When to Use Assist/Control?**
- This mode is most often used when mechanical ventilation is first initiated for a patient because this mode provides full ventilatory support.
- That is also one of the advantages of using Assist/Control because it keeps the patient's work of breathing requirement very low.
- One of the major complications of Assist/Control is hyperventilation, which results in respiratory alkalosis. This is the result of too many breaths given to the patient, whether patient triggered or machine-triggered.

Synchronous Intermittent Mandatory Ventilation (SIMV) Mode

- In this mode, the ventilator delivers a preset minimum number of mandatory breaths. However, it also allows the patient to initiate his own spontaneous breaths in between the mandatory ventilator breaths.
- This mode also allows the operator to set either a controlled pressure or a controlled volume.
- **When to Use SIMV?**
- The primary indication for SIMV is when a patient needs partial ventilatory support. That is because, since the patient can takes spontaneous breaths, that means they can contribute to some of their minute ventilation.
- SIMV is a mode that is used for weaning as well.

- **Advantages of Using SIMV:**
- • Since the patient is able to take spontaneous breaths, it helps
- to maintain their respiratory muscle strength and avoid muscular atrophy.
- • It distributes tidal volumes evenly throughout the lung fields, which reduces V/Q mismatching.
- • It helps to decrease the patient's mean airway pressure.
- **As a Respiratory Therapist (or student),** SIMV and Assist/Control
- are the two ventilator modes that you should be most familiar with.

Spontaneous Ventilator Modes

- **Continuous Positive Airway Pressure (CPAP)**
- In CPAP, or continuous positive airway pressure, a continuous pressure that is above atmospheric pressure is maintained throughout the breathing cycle. The patient must be breathing spontaneously to be in this mode
- because no mandatory breaths are given. This is a useful mode for
- weaning patients off of the ventilator.
- **Pressure Support Ventilation (PSV)**
- A mode of mechanical ventilation in which the patient's spontaneous breaths are supported by the ventilator during the inspiratory phase of breathing. As the patient triggers a breath, the ventilator assists by adding pressure to make breathing easier.
- The level of pressure is preset by the operator, so you have control over how much support you give the patient. For example, the higher the level of pressure support that is set, the easier it will be for the patient to take a breath. So this mode decreases work of breathing by overcoming the resistance of the ventilator tubes.

Other Ventilator Modes

- Now that we've covered the primary and spontaneous modes of ventilation, now let's go through the unconventional ventilator modes. These are sometimes referred to as the secondary modes of ventilation.
- 1. Control Mode Ventilation (CMV) ,locks out patient's effort to breath
- 2. Airway Pressure Release Ventilation (APRV)
- 3. Mandatory Minute Ventilation (MMV)
- 4. Inverse Ratio Ventilation (IRV)
- 5. Pressure Regulated Volume Control (PRVC)
- 6. Proportional Assist Ventilation (PAV)
- 7. Adaptive Support Ventilation (ASV)
- 8. Adaptive Pressure Control (APC)
- 9. Volume-Assured Pressure Support (VAPS)
- 10. Neurally Adjusted Ventilatory Assist (NAVA)
- 11. Automatic Tube Compensation (ATC)
- 12. High-Frequency Oscillatory Ventilation (HFOV)

INITIAL SETTINGS

- Select your mode of ventilation
- Set sensitivity at Flow trigger mode
- Set Tidal Volume
- Set Rate
- Set Inspiratory Flow (if necessary)
- Set PEEP
- Set Pressure Limit
- Inspiratory time
- Fraction of inspired oxygen

Trigger

- There are two ways to initiate a ventilator-delivered breath: pressure triggering or flow-by triggering
  - When pressure triggering is used, a ventilator-delivered breath is initiated if the demand valve senses a negative airway pressure deflection (generated by the patient trying to initiate a breath) greater than the trigger sensitivity.
  - When flow-by triggering is used, a continuous flow of gas through the ventilator circuit is monitored. A ventilator-delivered breath is initiated when the return flow is less than the delivered flow, a consequence of the patient's effort to initiate a breath

Positive End-Expiratory Pressure (PEEP)

- Applied PEEP is generally added to mitigate end-expiratory alveolar collapse. A typical initial applied PEEP is 5 cmH2O. However, up to 20 cmH2O may be used in patients undergoing low tidal volume ventilation for acute respiratory distress syndrome (ARDS)

Flow Rate

- The inspiratory flow rate is a rate that controls how fast a tidal

volume is delivered by the ventilator. The setting can be adjusted depending on the patient's inspiratory demands.

- The normal inspiratory flow rate should be set at around 60 L/min. With that said, most ventilators can deliver up to 120 L/min if a patient needs a prolonged expiratory which is necessary when obstructive diseases are present .

- If the flow rate is set too low, it could result in patient-ventilator

dyssynchrony and an increased work of breathing. If the flow rate Is set too high, it could result in decreased mean airway pressures

Inspiratory Time: Expiratory Time Relationship (I:E Ratio)

- During spontaneous breathing, the normal I:E ratio is 1:2, indicating that for normal patients the exhalation time is about twice as long as inhalation time.
- If exhalation time is too short “breath stacking” occurs resulting in an increase in end-expiratory pressure also called auto-PEEP.
- Depending on the disease process, such as in ARDS, the I:E ratio can be changed to improve ventilation

Ventilator Alarms

- A ventilator alarm is a safety mechanism on a mechanical ventilator that uses set parameters to provide alerts whenever there is a potential problem related to the patient-ventilator interaction.
- Common Ventilator Alarms Include:
- • High Pressure
- • Low Pressure
- • Low Expired Volume
- • High Frequency
- • Apnea
- • High PEEP
- • Low PEEP

Guidelines in the Initiation of Mechanical Ventilation

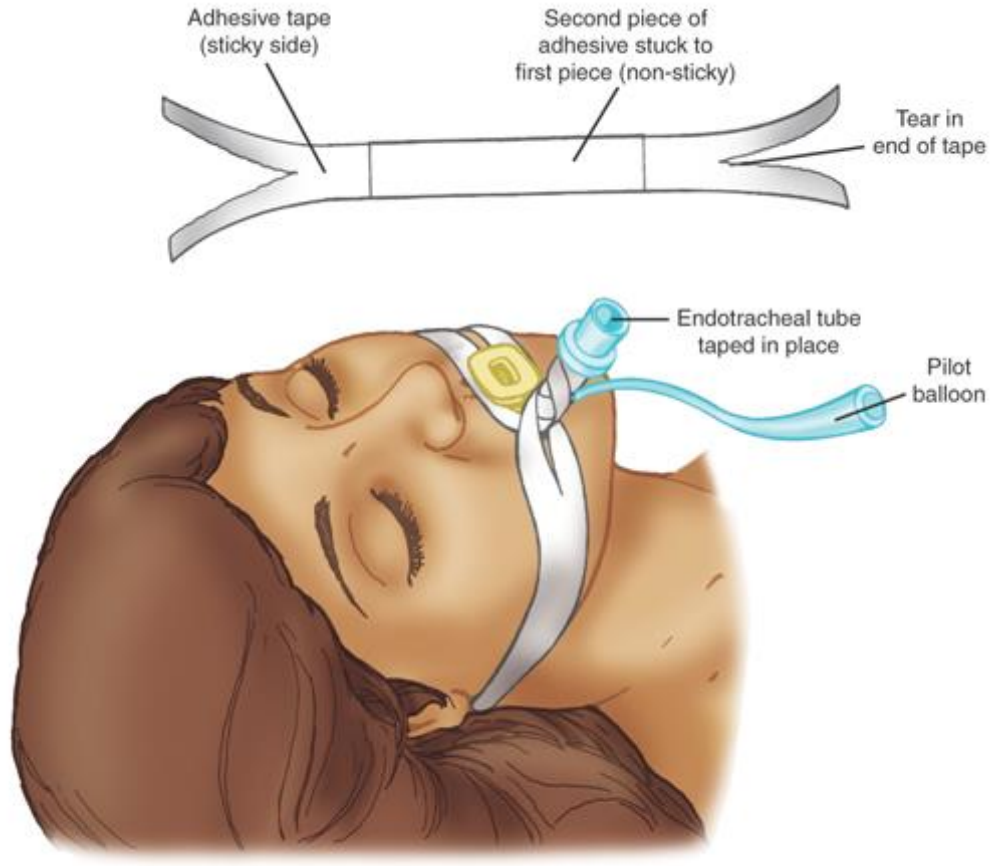
- Primary goals of mechanical ventilation are adequate oxygenation/ventilation, reduced work of breathing, synchrony of vent and patient, and avoidance of high peak pressures
- Set initial FIO2 on the high side, you can always titrate down
- Initial tidal volumes should be 8-10ml/kg, depending on patient's body habitus. If patient is in ARDS consider tidal volumes between 5-8ml/kg with increase in PEEP

- Use PEEP in diffuse lung injury and ARDS to support oxygenation and reduce FIO2
- Avoid choosing ventilator settings that limit expiratory time and cause or worsen auto PEEP
- When facing poor oxygenation, inadequate ventilation, or high peak pressures due to intolerance of ventilator settings consider sedation, analgesia or neuromuscular blockage

Intubation Procedure

Check and Assemble Equipment:

- ✓Oxygen flowmeter and O2 tubing
- ✓Suction apparatus and tubing
- ✓Suction catheter
- ✓Ambu bag and mask
- ✓Laryngoscope with assorted blades
- ✓3 sizes of ET tubes
- ✓Stillet
- ✓Stethoscope
- ✓Tape
- ✓Syringe
- ✓Sterile gloves



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Post Initial Settings

- Obtain an ABG (arterial blood gas) about 30 minutes after you set your patient up on the ventilator.
- An ABG will give you information about any changes that may need to be made to keep the patient's oxygenation and ventilation status within a physiological range.

ABG

- Goal:
- Keep patient's acid/base balance within normal range:

  - pH 7.35 – 7.45
  - PCO_2 35-45 mmHg
  - PO2 80-100 mmHg

Noninvasive Ventilation (NIV):

- Noninvasive Ventilation (NIV) involves the administration of ventilatory support without using any type of invasive artificial airway. Instead, NIV uses a mask that tightly seals to the face in order to provide ventilatory support.
- **Indications for Noninvasive Ventilation:**
- • Acute respiratory failure
- • Congestive Heart Failure (CHF)
- • Pulmonary Edema
- • Severe Dyspnea
- • A Do Not Resuscitate (DNI) order is in effect
- Noninvasive ventilation is often used in order to avoid the
- complications that are associated with invasive Mechanical
- Ventilation.
- **There are two primary types of Noninvasive Ventilation:**
- • BiPAP
- • CPAP

- **What is Bilevel Mechanical Ventilation?**
- Bilevel Positive Airway Pressure (BiPAP) is a form of noninvasive ventilation that distributes two levels of pressure in order to provide ventilatory support for the patient. It’s one of the two forms of noninvasive ventilation, CPAP being the other.

COMPLICATIONS OF M.V

Complications of Endotracheal Intubation

- **Cuff problems**
  - **Ineffective seal leads to aspiration**
  - **Too much pressure leads to tracheal necrosis**
  - **Use minimal occluding volume (keep pressure <20 mm Hg)**
  - **Suction throat before deflation**

- **Barotrauma**
- This is a condition in which the alveoli of the lungs rupture due to overinflation from increased pressure levels. As a result, the lungs collapse which leads to very serious lung conditions that can affect breathing.
- **Volutrauma**
- This condition occurs when the alveoli become filled with oedema fluid due to high tidal volumes during inhalation.with resultant over distention and stretching of the alveoli which lead to acute oedema . Volutrauma commonly occurs in patients with Acute Respiratory Distress Syndrome (ARDS.
- Tension pneumothorax which is presented by sever hypotention

- **Ventilator-Associated Pneumonia (VAP)**
- This condition is a lung infection that develops 48 hours or more after a patient has been intubated and placed on the ventilator. Because Mechanical Ventilation involves the insertion of tubes into the airway, this increases the chances of various microorganisms entering the lungs.
- **Auto-PEEP**
- Auto-PEEP, or Intrinsic PEEP, is characterized by over-inflation of the lungs due to large tidal volumes, restrictive airways, or a prolonged inhalation time. If left untreated, this condition can progress to barotrauma and collapsed lungs.
- **Oxygen Toxicity**
- This occurs when a patient receives too much oxygen for too long of a period of time. In general, patients who receive an $FiO_2 > 60\%$ for extended periods of time are at risk of oxygen toxicity.

Decreased Cardiac Output

- **Cause** - venous return to the right atrium impeded by the dramatically increased intrathoracic pressures during inspiration from positive pressure ventilation.
- **Symptoms** – increased heart rate,
- decreased blood pressure and perfusion to vital organs, decreased CVP,
- and cold extremities.
- **Treatment** – aimed at increasing preload (e.g. fluid administration) and decreasing the airway pressures exerted during mechanical ventilation by decreasing inspiratory flow rates and TV, or using other methods to decrease airway pressures (e.g. different modes of ventilation).

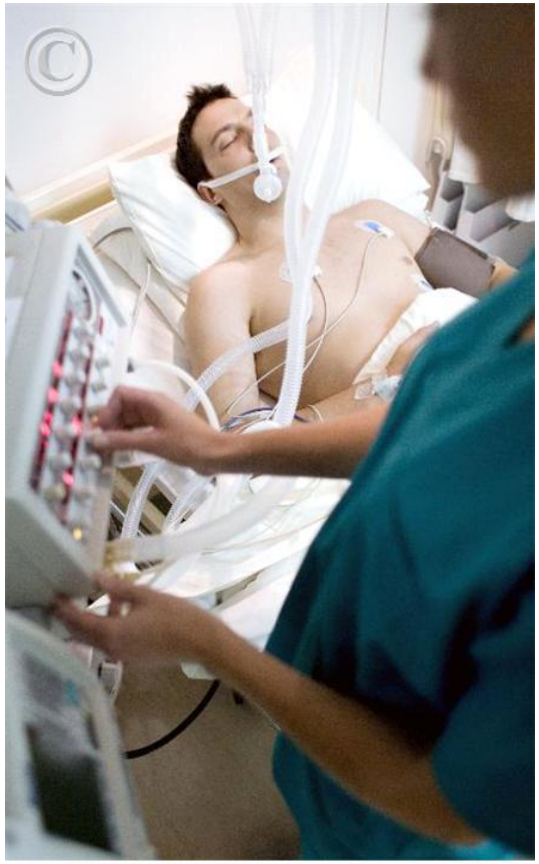
NURSING MANAGEMENT OF VENTILATED PATIENT

Nursing Management:

1. Promote respiratory function.
2. Monitor for complications
3. Prevent infections.
4. Provide adequate nutrition.
5. Monitor GI bleeding.

PROMOTE RESPIRATORY FUNCTION

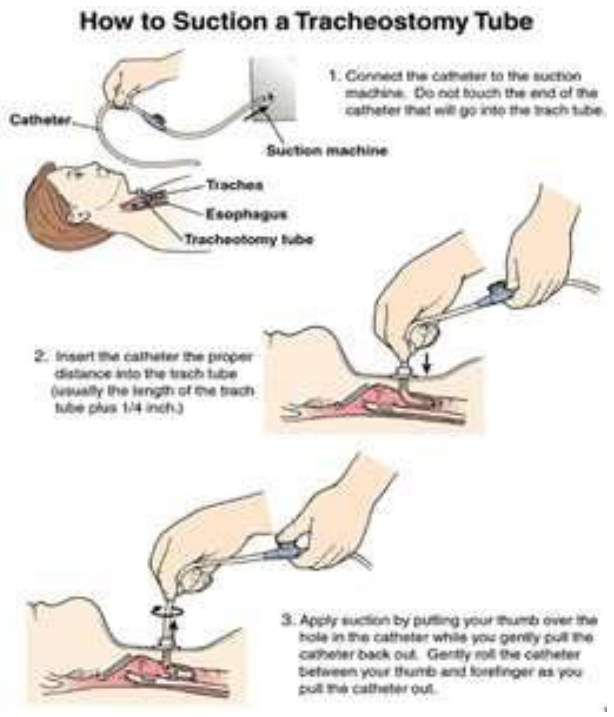
1. Auscultate lungs frequently to assess for abnormal sounds.
2. Suction as needed.
3. Turn and reposition every 2 hours.
4. Secure ETT properly.
5. Monitor ABG value and pulse oximetry.



SUCTION OF AN ARTIFICIAL AIRWAY

1. To maintain a patent airway
2. To improve gas exchange.
3. To obtain tracheal aspirate specimen.
4. To prevent effect of retained secretions.

(Its important to OXYGENATE before and after suctioning)



MONITOR FOR COMPLICATIONS

1. Assess for possible early complications
   Rapid electrolyte changes.
   Severe alkalosis.
   Hypotension secondary to change in
   Cardiac output.

2. Monitor for signs of respiratory distress:
   Restlessness

Irritability and increase HR.

3. Assess for signs and symptoms of barotrauma(rupture of the lungs)
   - Increasing dyspnea
   - Agitation
   - Decrease or absent breath sounds.
   - Decreasing PaO2 level .

4. Assess for cardiovascular depression:
   - Hypotension
   - Tachy. and Bradycardia
   - Dysrhythmias.

TROUBLESHOOTING

Increase in patient agitation and dis-synchrony on the ventilator:

Could be secondary to overall discomfort

Increase sedation

Could be secondary to feelings of air hunger

Options include increasing tidal volume, increasing flow rate, adjusting I:E ratio, increasing sedation

Low Pressure Alarm

- Usually due to a leak in the circuit.
  - Attempt to quickly find the problem
  - Bag the patient and call your RT.

High Pressure Alarm

- Usually caused by:
  - A blockage in the circuit (water condensation)
  - Patient biting his ETT
  - Mucus plug in the ETT

  - You can attempt to quickly fix the problem

- If peak pressures are increasing:
  - Check plateau pressures by allowing for an inspiratory pause (this gives you the pressure in the lung itself without the addition of resistance)
  - If peak pressures are high and plateau pressures are low then you have an obstruction
  - If both peak pressures and plateau pressures are high then you have a lung compliance issue

Trouble Shooting the Vent

- High peak pressure differential:

High Peak Pressures Low Plateau Pressures	High Peak Pressures High Plateau Pressures
Mucus Plug	ARDS
Bronchospasm	Pulmonary Edema
ET tube blockage	Pneumothorax
Biting	ET tube migration to a single bronchus
	Effusion

Accidental Extubation

- **Role of the Nurse**:
  - Ensure the Ambu bag is attached to the oxygen flowmeter and it is on!
  - Attach the face mask to the Ambu bag and after ensuring a good seal on the patient's face; supply the patient with ventilation.

Weaning

- Monitor closely
  - resp rate
  - accessory muscle use
  - shallow respirations
  - paradoxical breathing
  - ABGs
    - rising PCO_2 → acidosis
    - falling PO2
    - BP (↓ or ↑)
    - LOC (restless, tiring, somnolence, anxiety)
    - Pulse oximeter

QUESTIONS!!!


Thank You

Ventilator circuit

Breathing system plain

Ventilator Breathing System (1.6m)

Ventilator Breathing System (1.6m)

heat & moisture exchanger HME filter


Aerogen

Emergencies in diabetes

1. Hypoglycemic coma
2. Hyperglycemic ketoacidotic coma
3. Hyperglycemic hyperosmolar (nonketoacidotic) coma

Hyperglycemia

Causes of Hyperglycemia

Too much food

Not enough insulin or Medication

Illness

Stress and infections

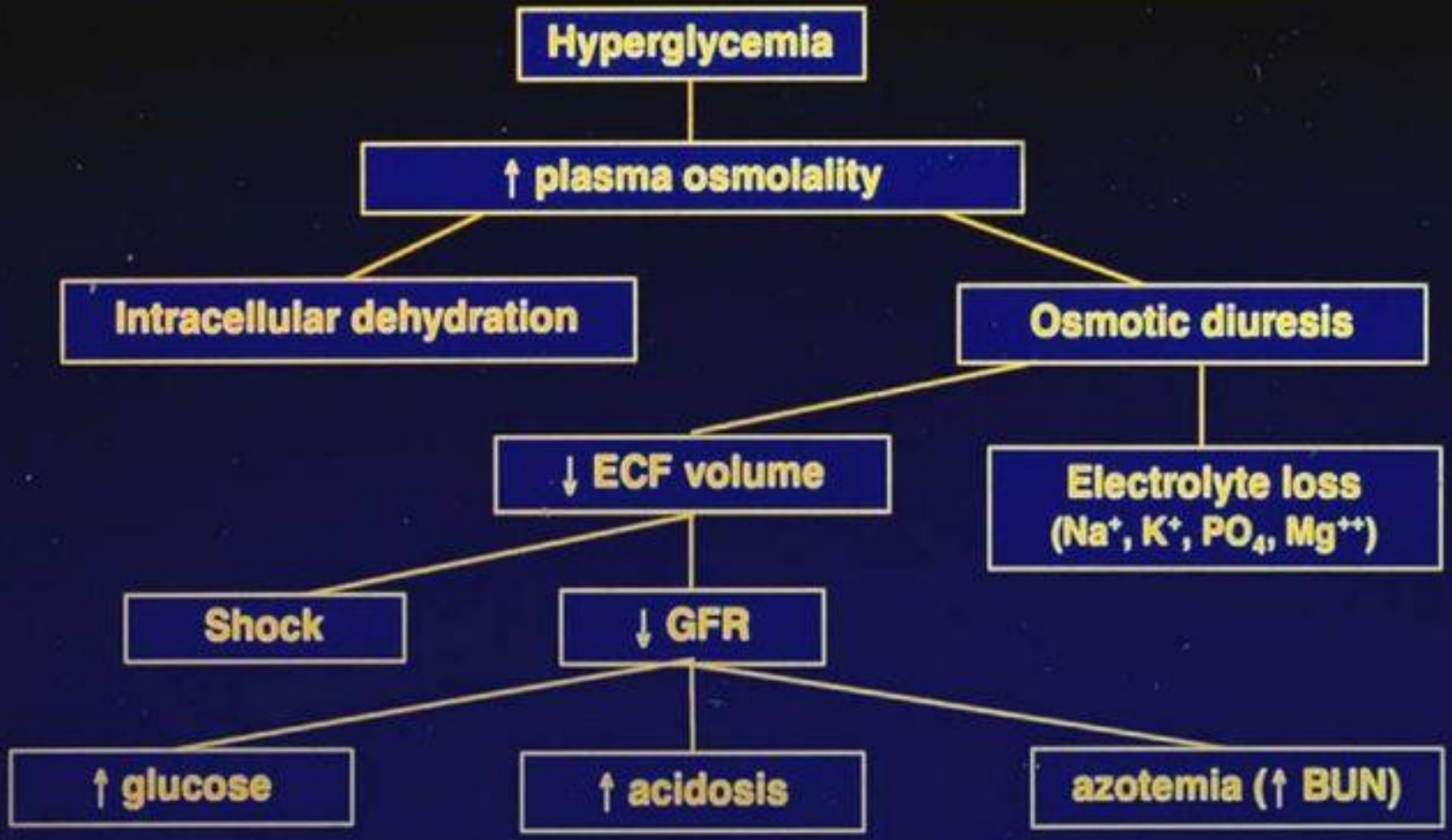
Hyperglycemic ketoacidotic coma (DKA)

Precipitating factors of DKA

1. newly diagnosed diabetes (presenting manifestation);
2. inadequate administration of exogenous insulin;
3. increased requirements for insulin caused by the presence of an underlying stressful condition:

- an intercurrent infection (pneumonia, pyelonephritis, cholecyctitis…);
- a vascular disorder (myocardial infarction, stroke);
- an endocrine disorder(hyperthyroidism, pheochromocytoma);
- trauma;
- pregnancy;
- surgery

Diabetic Ketoacidosis



Pathophysiology of diabetic ketoacidosis

- Clinical forms of DKA

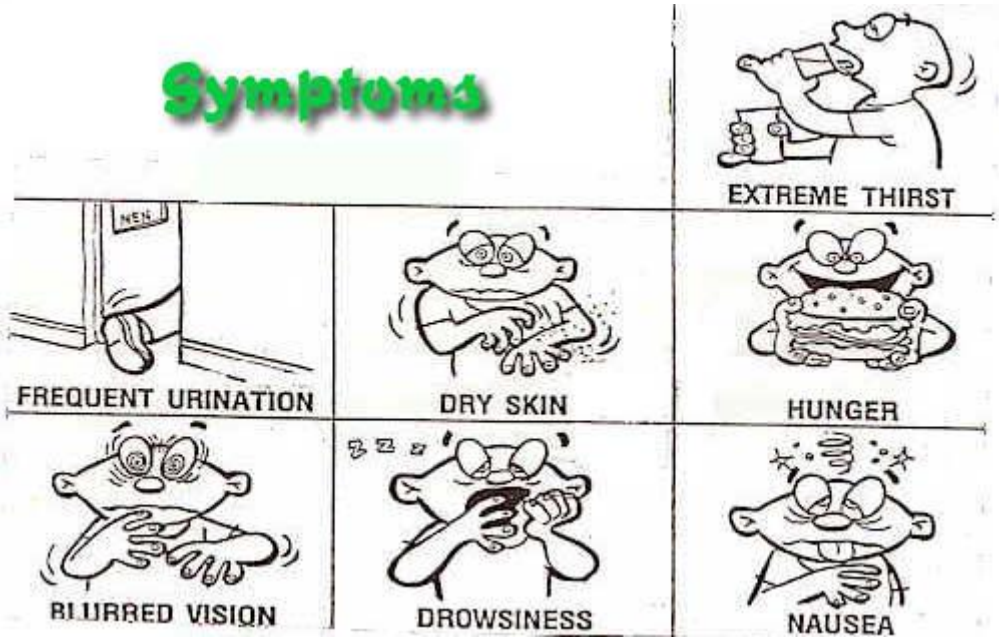
  - gastrointestinal (abdominal)
  - cardiovascular
  - renal (nephrotic)
  - pseudocerebral (encephalopathy)
  - dehydration form.

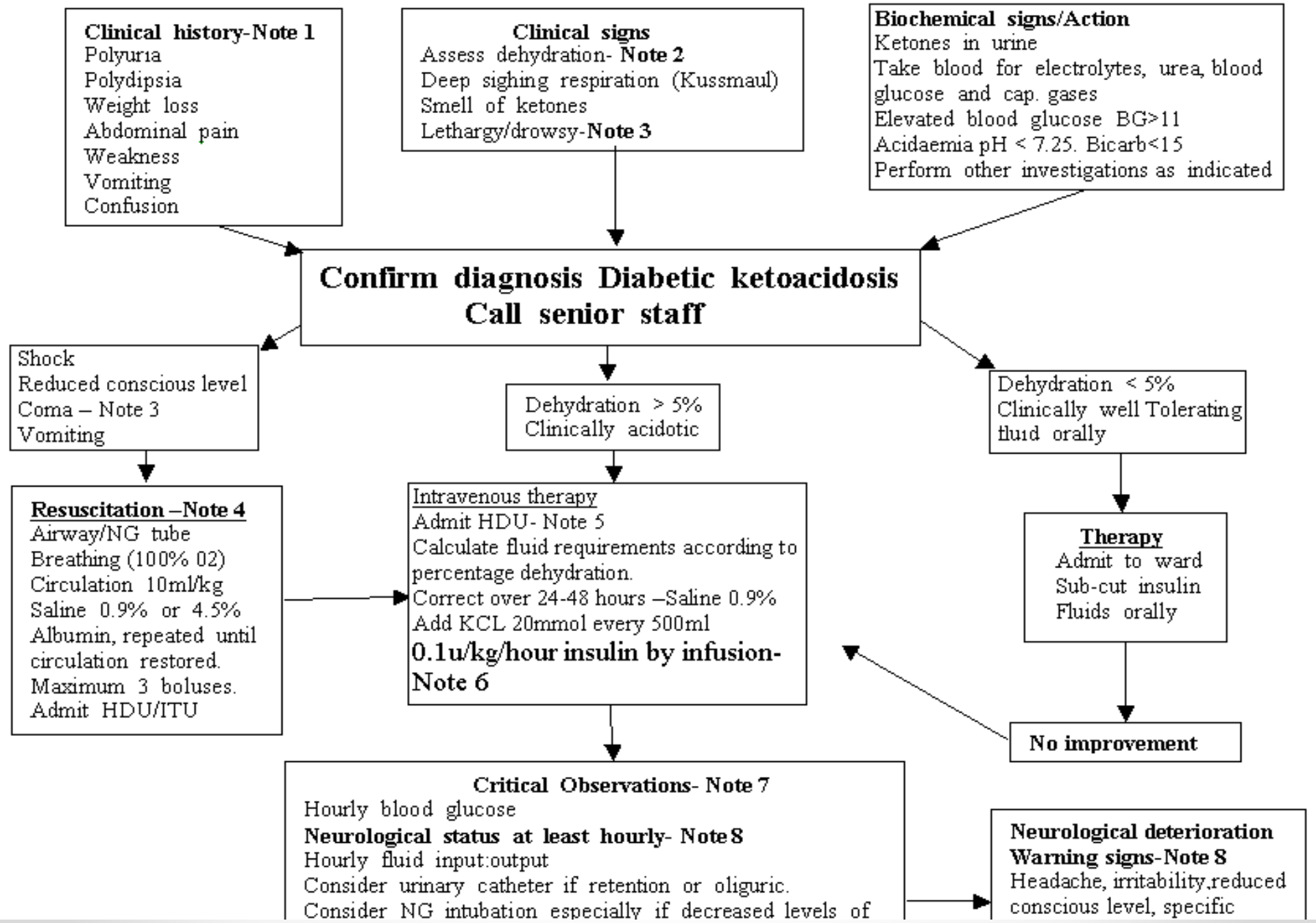
Clinical symptoms of ketoacidosis

- **Early stage (typical symptoms of diabetes decompensation)**
- dryness of the skin and mucous membranes
- thirst, polyuria
- weight loss
- weakness, headache, drowsiness, smell of acetone in exhaled air
- decreased appetite, nausea and abdominal pain which could be mistaken by gastroenteritis in children .

- **Precoma, coma:**
  - dizziness
  - nausea, vomiting, abdominal pain
  - severe dehydration (loss of up to 10 - 12% of body weight), decreased muscle tone
  - tachycardia, decreasing of body temperature, blood pressure, tone eyeballs
  - oliguria, anuria
  - loss of consciousness, Kussmaul breathing, sharp smell of acetone

Symptoms


EXTREME THIRST
FREQUENT URINATION
DRY SKIN
HUNGER
BLURRED VISION
DROWSINESS
NAUSEA


Clinical history-Note 1
Polyuria
Polydipsia
Weight loss
Abdominal pain
Weakness
Vomiting
Confusion
Clinical signs
Assess dehydration- Note 2
Deep sighing respiration (Kussmaul)
Smell of ketones
Lethargy/drowsy-Note 3
Biochemical signs/Action
Ketones in urine
Take blood for electrolytes, urea, blood glucose and cap. gases
Elevated blood glucose BG>11
Acidaemia pH < 7.25. Bicarb<15
Perform other investigations as indicated
Confirm diagnosis Diabetic ketoacidosis
Call senior staff
Shock
Reduced conscious level
Coma – Note 3
Vomiting
Dehydration > 5%
Clinically acidotic
Dehydration < 5%
Clinically well Tolerating fluid orally
Resuscitation –Note 4
Airway/NG tube
Breathing (100% 02)
Circulation 10ml/kg
Saline 0.9% or 4.5%
Albumin, repeated until circulation restored.
Maximum 3 boluses.
Admit HDU/ITU
Intravenous therapy
Admit HDU- Note 5
Calculate fluid requirements according to percentage dehydration.
Correct over 24-48 hours –Saline 0.9%
Add KCL 20mmol every 500ml
0.1u/kg/hour insulin by infusion-Note 6
Therapy
Admit to ward
Sub-cut insulin
Fluids orally
No improvement
Critical Observations- Note 7
Hourly blood glucose
Neurological status at least hourly- Note 8
Hourly fluid input:output
Consider urinary catheter if retention or oliguric.
Consider NG intubation especially if decreased levels of
Neurological deterioration
Warning signs-Note 8
Headache, irritability,reduced conscious level, specific

The Management of Diabetic Ketoacidosis in Adults

Where individuals aged 16-18 are managed by paediatric teams, the paediatric guidelines should be followed:
https://www.bsped.org.uk/media/1943/bsped-guideline-for-the-management-of-children-and-young-people-under-the-age-of-18-years-with-diabetic-ketoacidosis-2021.pdf"

Diagnostic criteria: **all three of the following must be present**

- capillary blood glucose above 11 mmol/L
- capillary ketones above or equal to 3 mmol/L or urine ketones ++ or more
- venous pH less than 7.3 and/or bicarbonate less than or equal to 15 mmol/L

BOX 1: Immediate management: time 0 to 60 minutes

(T=0 at time intravenous fluids are commenced)

If intravenous access cannot be obtained request critical care support immediately

Action 1: Commence 0.9% sodium chloride solution (use a large bore cannula) via an infusion pump
See Box 2 for rate of fluid replacement

Action 2: Commence a fixed rate intravenous insulin infusion (FRIII). (0.1 unit/kg/hr based on estimate of weight) 50 units human soluble insulin (Actrapid® or Humulin S®) made up to 50 ml with0.9% sodium chloride solution. If patient normally takes long acting insulin analogue (glargine, detemir, degludec) continue at usual dose and time

Action 3: Assess patient
- Respiratory rate; temperature; blood pressure; pulse; oxygensaturation
- Glasgow Coma Scale
- Full clinical examination

Action 4: Further investigations
- Capillary and laboratory glucose
- Venous BG
- U&E and FBC
- Blood cultures
- ECG
- CXR
- MSU

Action 5: Establish monitoring regimen
- Hourly capillary blood glucose
- Hourly capillary ketone measurement if available
- Venous bicarbonate and potassium at 60 minutes, 2hours and 2 hourly thereafter
- 4 hourly serum electrolytes
- Continuous cardiac monitoring if required
- Continuous pulse oximetry if required

Action 6: Identify and manage precipitating cause

HDU/level 2 facility and/or insertion of central line may be required in following circumstances (request urgent senior review)

- Young people aged 18-25 years
- Elderly
- Pregnant
- Heart or kidney failure
- Other serious co-morbidities
- Severe DKA by following criteria
  - Blood ketones above 6 mmol/L
  - Venous bicarbonate below 5 mmol/L
- Venous pH below 7.1
- Hypokalaemia on admission (below 3.5 mmol/L)
- GCS less than 12
- Oxygen saturation below 92% on air (Arterial blood gases required)
- Systolic BP below 90 mmHg
- Pulse over 100 or below 60 bpm
- Anion gap above 16 [Anion Gap = $(Na^+ + K^+) – (Cl^- + HCO_3^-)$]

BOX 2: Initial fluid replacement

Restoration of circulating volume is priority

Systolic BP (SBP) below 90 mmHg

Likely to be due to low circulating volume, but consider other causes such as heart failure, sepsis, etc.

- Give 500 mls 0.9% sodium chloride solution over 10–15 minutes. If SBP remains <90 mmHg repeat whilst awaiting senior input. Most people require between 500-1000 mls given rapidly
- Involve the ITU / critical care team if the SBP remains <90mmHg after 2 IV fluid boluses
- Once SBP is >90 mmHg, give 1 L 0.9% sodium chloride over the next 60 minutes. The addition of potassium is likely to be required in this second litre of fluid

Systolic BP on admission 90 mmHg and over

- Give 1 L 0.9% sodium chloride over the first 60 minutes

Potassium replacement Potassium level (mmol/L)	Potassium replacement mmol/L of infusion solution
>5.5	Nil
3.5-5.5	40 mmol/L
<3.5	senior review – additional potassium required

BOX 3: 60 minutes to 6 hours

Aims of treatment:
- Rate of fall of ketones of at least 0.5 mmol/L/hr OR bicarbonate rise 3 mmol/L/hr and blood glucose fall 3 mmol/L/hr
- Maintain serum potassium in normal range
- Avoid hypoglycaemia

Action 1: Re-assess patient, monitor vital signs
- Hourly blood glucose (lab blood glucose if meter reading 'HI')
- Hourly blood ketones if meter available
- Venous blood gas for pH, bicarbonate and potassium at 60 minutes, 2 hours and 2 hourly thereafter
- If potassium is outside normal range, re-assess potassium replacement and checkhourly. If abnormal after further hour seek immediate senior medical advice.

Action 2: Continue fluid replacement via infusion pump as follows:
- 0.9% sodium chloride 1 L with potassium chloride over next 2 hours
- 0.9% sodium chloride 1 L with potassium chloride over next 2 hours
- 0.9% sodium chloride 1 L with potassium chloride over next 4 hours
- Add 10% glucose 125 ml/hr if blood glucose falls below 14 mmol/L
- **Consider** reducing the rate of intravenous insulin infusion to 0.05 units/kg/hour when glucose falls below 14 mmol/L

More cautious fluid replacement in people aged 18-25 years, elderly, pregnant, heart or renal failure. (Consider HDU admission)

Action 3: Assess response to treatment

Insulin infusion rate may need review if
- Capillary ketones not falling by at least 0.5 mmol/L/hr
- Venous bicarbonate not rising by at least 3 mmol/L/hr
- Plasma glucose not falling by at least 3 mmol/L/hr
- Continue FRIII until ketones less than 0.3 mmol/L, venous pH >7.3 and/or venous bicarbonate over 18 mmol/L

If ketones and glucose are not falling as expected always check the insulin infusion pump is working and connected and that the correct insulin residualvolume is present (to check for pump malfunction).

If equipment working but response to treatment is inadequate, increase insulin infusionrate by 1 unit/hr increments hourly until targets achieved.

Additional measures
- Regular observations and Early Warning Score (NEWS2)
- Accurate fluid balance chart, minimum urine output 0.5 ml/kg/hr
- Consider urinary catheterisation if incontinent or anuric (not passed urine) by 60 minutes
- Nasogastric tube with airway protection if patient obtunded or persistently vomiting
- Measure arterial blood gases and repeat chest radiograph if oxygen saturation lessthan 92%
- Thromboprophylaxis with low molecular weight heparin
- Consider ECG monitoring if potassium abnormal or concerns about cardiac status

BOX 4: 6 to 12 hours

Aims:
- Ensure clinical and biochemical parameters improving
- Continue IV fluid replacement
- Avoid hypoglycaemia
- Assess for complications of treatment e.g. fluid overload, cerebral oedema
- Treat precipitating factors as necessary

Action 1: Re-assess patient, monitor vital signs
- If patient not improving by criteria in Box 3, seek senior advice
- Continue IV fluid via infusion pump at reduced rate
  - 0.9% sodium chloride 1 L with KCl over 4 hours
  - 0.9% sodium chloride with KCl over 6 hours
- Add 10% dextrose 125 mls/hr if the glucose falls below 14 mmol/L
- **Consider** reducing the rate of intravenous insulin infusion to 0.05 units/ kg/hour when glucose falls below 14 mmol/L

Reassess cardiovascular status at 12 hours; further fluidmay be required

Check for fluid overload

Action 2 – Review biochemical and metabolic parameters
- At 6 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose
- Resolution of DKA is defined at ketones <0.3 mmol/L **AND** venous pH >7.3 (do not use bicarbonate as a marker at this stage)
- Ensure a referral has been made to the diabetes team
- **If DKA not resolved review insulin infusion (see BOX 3Action 3)**
- **If DKA resolved go to BOX 6**

BOX 5: 12 to 24 HOURS

Expectation: By 24 hours the ketonaemia and acidosis should have resolved. Request senior review if not improving

Aim:
- Ensure that clinical and biochemical parameters are continuing to improve or are normal
- Continue IV fluid replacement if not eating and drinking
- If ketonaemia has cleared and the person is not eating or drinking, move to a variable rate intravenous insulin infusion (VRIII) as per local guidelines
- Reassess for complications of treatment, e.g. fluid overload, cerebral oedema
- Continue to treat precipitating factors
- Transfer to subcutaneous insulin if the person is eating and drinking normally and biochemistry is normal

Action 1 – Re-assess patient, monitor vital signs

Action 2 – Review biochemical and metabolic parameters
- At 12 hours check venous pH, bicarbonate, potassium, capillary ketones and glucose
- Resolution is defined as ketones <0.3 mmol/L, venous pH>7.3
- If not resolved review fluid **Box 4 Action 1** and insulin infusion **Box 3 Action 3**

If DKA resolved go to Box 6

BOX 6: Resolution of DKA

Expectation: Patient should be eating and drinking and back on normal insulin

If DKA not resolved identify and treat the reasons for failure to respond.
This situation is unusual and requires senior and specialist input

Transfer to subcutaneous insulin

Convert to subcutaneous regime when biochemically stable (capillary ketones less than 0.3 mmol/L **AND** pH over 7.3) and the patient is ready and able to eat. **Do not discontinue intravenous insulin infusion until 30 minutes after subcutaneous short acting insulin has been given.** Conversion to subcutaneous insulin should be managed by the Specialist Diabetes Team. If the team is not available use local guidelines. If the patient is newly diagnosed it is essential they are seen by a member of the specialist team prior to discharge

Arrange follow up with specialist team

Represented: Association of British Clinical Diabetologists; British Society for Endocrinology and Diabetes and Association of Children's Diabetes Clinicians; Diabetes Inpatient Specialist Nurse (DISN) Group; Diabetes UK; Diabetes Network Northern Ireland; Society of Acute Medicine; Welsh Endocrine and Diabetes Society, Scottish Diabetes Group.

Assessment

- **History:**

Symptoms of hyperglycemia, precipitating factors , diet and insulin dose.

- **Examination:**

- **Look for signs of dehydration, acidosis, including shock, hypotension, acidotic breathing, CNS status…etc.**
- **Look for signs of hidden infections (Fever strongly suggests infection) and If possible, obtain accurate weight before starting treatment.**

Baseline Investigations

The initial Lab evaluation includes:

- **Plasma & urine levels of glucose & ketones.**
- **Electrolites (including Na, K, Ca, Mg, Cl, PO4, HCO3), & arterial pH.**
- **Venous pH is as accurate as arterial (deviation of 0.025 less than arterial pH)**
- **Complete Blood Count with differential.**
- **Further tests e.g., cultures, X-rays…etc , are done when needed.**

Pitfalls in DKA

- **High WBC: may be seen in the absence of infections.**
- **BUN: may be elevated with prerenal azotemia secondary to dehydration.**
- **Creatinine: some assays may cross-react with ketone bodies, so it may not reflect true renal function.**
- **Serum Amylase: is often raised, & when there is abdominal pain, a diagnosis of pancreatitis may mistakenly be made.**

Treatment

_The goals of therapy include:

1. Reduction of hyperglycemia
2. Rehydratation

3. Correction of electrolyte imbalance **In addition to insulin replacement and volume expansion, the most urgent goal in treatment of DKA includes prevention of hupokalemia.**

4. Correction of acid-base imbalance
5. Investigation of precipitating factors, treatment of complications.

- Resolving hyperglycemia alone is not the end point of therapy
  - Need resolution of the metabolic acidosis or inhibition of ketoacid production to signify resolution of DKA
  - Normalization of anion gap requires 8-16 hours and reflects clearance of ketoacids

Fluid Administration

- Restores:
  - Intravascular volume
  - Normal tonicity
  - Perfusion of vital organs
- Improve glomerular filtration rate
- Lower serum glucose and ketone levels
- Normal saline is most frequently recommended fluid for initial volume repletion
- *Glucose and ketone concentrations begin to fall with fluids alone*
  - May need to monitor CVP or wedge pressure in the elderly or those with heart disease and may risk ARDS and cerebral edema

Insulin

- Ideal treatment is with continuous IV infusion of small doses of regular insulin
- start infusing regular insulin at a rate of 0.1U/kg/hour using a syringe pump. Optimally, serum glucose should decrease in a rate no faster than 100mg/dl/hour.
- If serum glucose falls < 200 prior to correction of acidosis, add infusion of glucose with insulin.

Correction of Acidosis

Together with correction of dehydration normalize the blood PH.

- **Bicarbonate therapy should not be used unless severe acidosis (pH<7.0) results in hemodynamic instability. If it must be given, it must infused slowly over several hours.**

Must be monitoring of fluid balance & Lab measures.

- **serum glucose must be measured hourly.**
- **potassium should be followed up to prevent hypokalemia.**
- **Ca, Mg, & phosphate must be measured initially & at least once during therapy.**
- ***Neurological & mental state must examined frequently*, & any complaints of headache or deterioration of mental status should prompt rapid evaluation for possible cerebral ede ma.**

Nonketonic hyperglycemic-hyperosmolar coma (NKHHC or HNC).

HNC is a syndrome characterized by impaired consciousness, sometimes accompanied by seizures, extreme dehydration, and extreme hyperglycemia that is not accompanied by ketoacidosis.

Predisposing factors

1. HNC seems to occur spontaneously in about 5 – 7 % of patients.
2. Infection (e.g., pneumonia, urinary tract infection, gram-negative sepsis) is underlying frequent precipitating cause.
3. Use of certain drugs has been associated with this condition:

- steroids increase glucogenesis and antagonize the action of insulin;
- potassium-wasting diuretics (hypokalemia decreases insulin secretion), e.g., thiazides, furosemide;
- other drugs, e.g., propranolol, azathioprine, diazoxide.

5. Other medical conditions such as cerebrovascular accident, subdural hematoma, acute pancreatitis, and severe burns have been associated with HNC.
6. Use of concentrated glucose solutions, such as used in peripheral hyperalimentation or renal dialysis, has been associated with HNC.
7. HNC can be induced by peritoneal or hemodialysis, tube feeding.

Hyperosmolar hyperglycemic nonketotic coma(HHNC)
(hyperosmolar hyperglycemic syndrome)

a) - insulin is present to some degree → it inhibits fat breakdown → lack of ketosis

b) - insulin is present to some degree → its effectivity is less than needed for effective glucose transport → hyperglycemia → glycosuria and polyuria → body fluids depletion → intracellular dehydration → neurologic disturbancies (stupor, coma)

Physical examination

1. Severe dehydration is invariably present.
2. Various neurologic deficits (such as coma, transient hemiparesis, hyperreflexia, and generalized areflexia) are commonly present. Altered states of consciousness from lethargy to coma are observed.
3. Findings associated with coexisting medical problems (e.g., renal disease, cardiovascular disease) may be evident.

HHNS: Clinical Features

- Typical patient is usually elderly
- May complain of:
  - Weakness
  - Anorexia
  - Fatigue
  - Cough
  - Dyspnea
  - Abdominal pain

HHNS: Physical findings

- Non-specific
- Clinical signs of volume depletion:
  - Poor skin turgor
  - Dry mucus membranes
  - Sunken eyeballs
  - Hypotension
- Signs correlate with degree of hyperglycemia and hyperosmolality and duration of physiologic imbalance
- Wide range of findings such as changes in vital signs and cognition to clear evidence of profound shock and coma may occur
- Normothermia or hypothermia is common due to vasodilation

- Seizures
  - Up to 15% may present with seizures
  - Typically focal
  - Generalized seizures that are often resistant to anticonvulsants may occur
- Other CNS symptoms may include:
  - Tremor
  - Clonus
  - Hyperreflexia
  - Hyporeflexia
  - Positive plantar response
  - Reversible hemiplegia or hemisensory defects without CVA or structural lesion

Laboratory findings

1. Extreme hyperglycemia (blood glucose levels from 30 mmoll/l and over are common.
2. A markedly elevated serum osmolality is present, usually in excess of 350 mOsm/l. (Normal = 290 mOsm/l).
3. The initial plasma bicarbonate averaged.
4. Serum ketones are usually not detectable, and patients are not acidic.
5. Serum sodium may be high (if severe degree of dehydration is present), normal, or high (when the marked shift of water from the intracellular to the extracellular space due to the marked hyperglycemia is present).
6. Serum potassium levels may be high (secondary to the effects of hyperosmolality as it draws potassium from the cells), normal, or low (from marked urinary losses from the osmotic diuresis). But potassium deficiency exists.

Treatment

This condition is a medical emergency and the patient should be placed in an intensive care unit.

Many of the management techniques recommended for a patient with DKA are applicable here as well.

The goals of therapy include:

- rehydration;
- reduction of hyperglycemia;
- electrolytes replacement;
- investigation of precipitating factors, treatment of complications.

Rehydration

- With an osmolality > 320mOsm L and normal blood pressure treatment to begin with IV drip hypotonic (0.45 %) NaCl,
- in osmolarity < 320mOsm/l or low blood pressure - IV drip of isotonic (0.9%) NaCl
  - First hour : 1500 ml (15-30 ml / kg)
  - The second and third hour : 1000 ml
  - From the fourth hour, and then - 500 ml / hr
- After lowering glycemia below 14 mmol / l - replacement with saline NaCl at a 5% glucose solution with 500 ml / hour
- Termination of infusion therapy when recovering consciousness , no vomiting , the possibility of independent fluid intake

Hypoglycemia

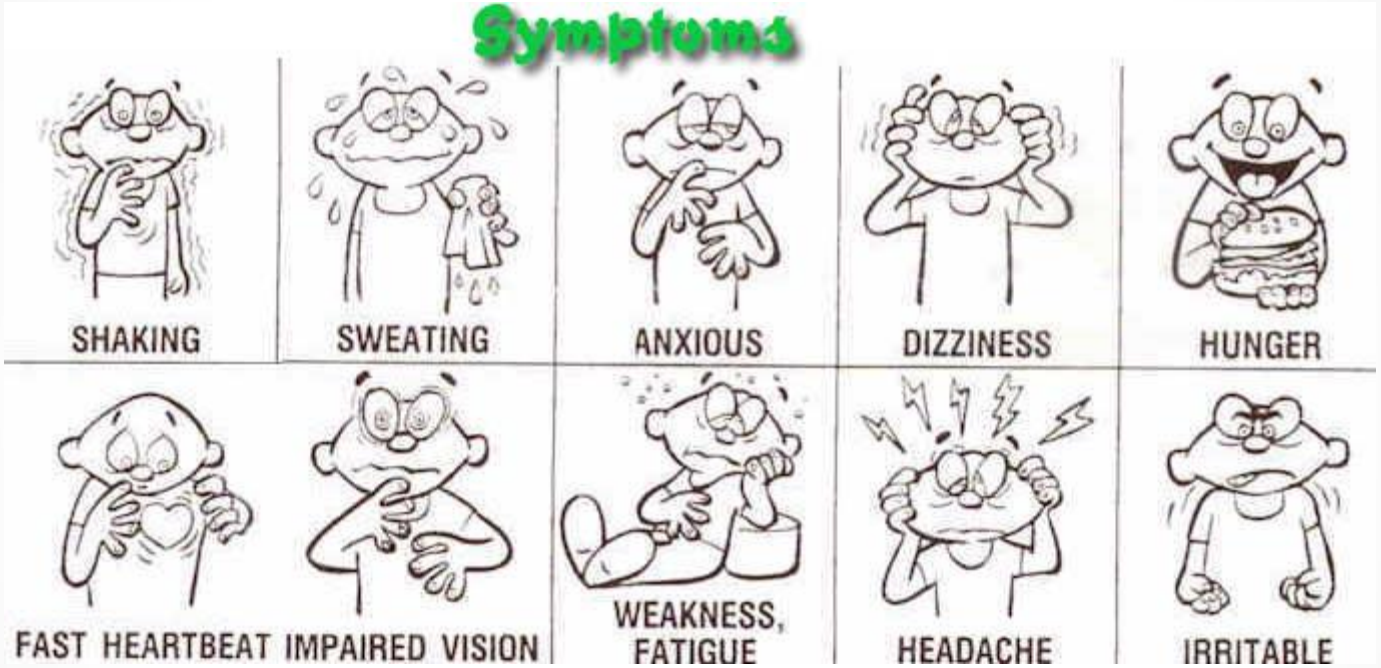
It is a syndrome characterized by symptoms of sympathetic nervous system stimulation or central nervous system dysfunction that are provoked by an abnormally low plasma glucose level.

Hypoglycemia represents insulin excess and it can occur at any time.

Precipitating factors

- irregular ingestion of food;
- extreme activity;
- **Drugs used for treatment of diabetes (most common)**
- alcohol ingestion;
- drug interaction;
- liver or renal disease;
- hypopituitarism and adrenal insufficiency.

Symptoms


SHAKING
SWEATING
ANXIOUS
DIZZINESS
HUNGER
FAST HEARTBEAT
IMPAIRED VISION
WEAKNESS, FATIGUE
HEADACHE
IRRITABLE

Physical examination

1. The skin is cold, moist.
2. Hyperreflexia can be elicited.
3. Hypoglycemic coma is commonly associated with abnormally low body temperature
4. Patient may be unconsciousness.

Laboratory findings

1. Low level of blood glucose

Treatment

- **Mild hypoglycemia**

  Taking easily digestible carbohydrates (sugar, sugary drinks) with repeated determination of glycemia in an hour, while maintaining hypoglycemia –

- **Hypoglycemic coma**

  IV bolus injection of 40% glucose solution 40 - 80 ml (if necessary – repeat injection to the full recovery of consciousness)

  intramuscularly or subcutaneously glucagon 1 mg

- **Important actions should be done if there is recurring hypoglycemia**

How to monitor your blood sugar levels

How to treat hypoglycemia

How and when to administer emergency hypoglycemia rescue therapy


THANKS FOR YOUR ATTENTION