Death as a process
Determining of clinical death
Establishing of unconsciousness or death.
Assessment of vital signs
Assessment of breathing, circulation, pupils and muscle tone

István Lőrincz MD, PhD
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Life

☐ For normal functioning all cells of the body require oxygen. If oxygen is not provided, death of organism appears within 4..5 minutes.

☐ Brain is the tissue most susceptible to anoxia (absence of oxygen).
Basic life functions (circulation, breathing) are inseparable parts of the existence and functioning of the human body.

During birth the human organism adapts to the external environment within a short time (1-2 mins) upon which process circulation and breathing fulfils the function that subsequently becomes a determining basis for all of body functions. If this adaptation does not happen without problems following birth, then external help might be needed.
If some damaging effect is present excessively it can lead to functional disorders or eventually to the deficiency of circulation or breathing. There are influences that come into being suddenly and may lead to the immediate stoppage of one of the basic life functions. The cessation of circulation and/or breathing in the body starts serious functional disorders, the damages of organs, tissues and cells.
Anoxemia in the body

The body is able to endure temporary relative shortage of oxygen (hypoxial state) without irreversible cellular damages for a few minutes but subsequently irreversible damages occur in some of the organs in case of a longer lasting lack of oxygen.

Certain tissues and cells of the human body possess a varying degree of oxygen shortage tolerance so the damages also appear in different rates. Our most sensitive cells that are incapable of regeneration are the neurons, consequently the cerebral tissue is the one that can sustain its life without oxygen and nutrients (glucose) for the shortest time (4-5 minutes) at regular temperature.
Eventually all cells will die if deprived of oxygen. Brain and heart are the most sensitive.
Example of time reference of SCD

**Prodromes**
- New or worsening cardiovascular symptoms
  - Chest pain
  - Palpitations
  - Dyspnea
  - Fatiguability

**Onset of terminal event**
- Abrupt change in clinical status
  - Arrhythmia
  - Hypotension
  - Chest pain
  - Dyspnea
  - Lightheadedness

**Cardiac arrest**
- Sudden collapse
  - Loss of effective circulation
  - Loss of consciousness

**Biological death**
- Failure of resuscitation
- OR
- Failure of electrical, mechanical, or CNS function after initial resuscitation

Days-to-months | Up to 1 hour | Minutes-to-weeks
The terminal states are the boundary ones between life and death.

This is also the dying, which include a few stages:

- pre-agony
- agony
- clinical death (reversible injury)
- biological death (irreversible injury)
The pre-agony is characterized by the diverse duration (during hours, days) of deep violations of the vitally important organism functions. The dyspnea, the decreasing of the arterial pressure, the darkening down of the consciousness, which are observed in this period. Gradually the pre-agony gets across in the agony.
The following warning signs of clinical death are:

- Prolapsed
- Worsening of breathing, change in the type of breathing
- Increased sweating, the skin quickly becoming pale, grey, cyanotic and suddenly cool
- Weakening of the pulse, its becoming irregular and hardly palpable
- Suddenly occurring chest pain or headache
- Convulsive attacks appear on the whole body
- The patient complains about fear of death
The terminal states

- The agony is characterized by the gradual turning down of all organism functions. The agony lasts 2-4 minutes, sometimes more.
The terminal states

- **The clinical death** is such condition when all of the visible sparks of life have already disappeared (the **breathing** and the **heart work** are ceased, however the **metabolism still continues**). The life can be restored on this stage.

- **The biological death** is characterized by the **irreversible changes** in the organism.
Brain death

Illustration 6/1 The life and death process from a biomedical point of view
Process of the death

Agony is a stage which precede to the death. Function of vital organs is severe disturbed, and conditions required for survival of organism cannot be met.

- Unconsciousness
- Blood pressure is undetectable
- No pulse on arteries

Clinical death: circulation stops completely and that leads to the cessation of breathing and nervous system activity.
Clinical death

Clinical death is the medical term for cessation of blood circulation and breathing, the two necessary criteria to sustain human and many other organisms' lives. It occurs when the HEART stops beating in a regular rhythm, a condition called cardiac arrest. Stopped blood circulation has historically proven irreversible in most cases. Prior to the invention of CPR, defibrillation, epinephrine injection, and other treatments in the 20th century, the absence of blood circulation (and vital functions related to blood circulation) was historically considered the official definition of death.
Symptoms of clinical death

- No pulse on arteries (carotid or femoral)
- Change of skin colour
- Unconsciousness
- Gasping, cessation of breathing
- Dilatation of eye pupils

Duration of clinical death is 3(5) minutes
**Process of the death**

**Biological death** is irreversible condition. Metabolism and functioning of vital organs has completely ceased. Organ damage is as extensive that resuscitation of the body is impossible.

**Evident symptoms of the death:**
- Rigor mortis
- Death spots on the body
- Drop of body temperature to the level of the surrounding
Death as a process.

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Clinical death

With the advent of these strategies, cardiac arrest came to be called *clinical death* rather than simply *death*, to reflect the possibility of post-arrest resuscitation. For medical purposes, it is considered the final physical state before legal death.

At the onset of clinical death, consciousness is lost within several seconds. Measurable *brain* activity stops within 20 to 40 seconds. *Irregular gasping* may occur during this early time period, and is sometimes mistaken by rescuers as a sign that CPR is not necessary. During clinical death, all tissues and organs in the body steadily accumulate a type of injury called *ischemic injury*. 
Clinical death

- When the heartbeat stops, a person is suffering clinical death - by definition.
- But consciousness is not lost until 15–20 seconds later.
- Most tissues and organs of the body can survive clinical death for considerable periods. Blood circulation can be stopped in the entire body below the heart for at least 30 minutes, with injury to the spinal cord being a limiting factor.
- Detached limbs may be successfully reattached after 6 hours of no blood circulation at warm temperatures.
- Bone, tendon, and skin can survive as long as 8 to 12 hours.
Clinical death

The brain, however, appears to accumulate ischemic injury faster than any other organ. Without special treatment after circulation is restarted, full recovery of the brain after more than 3 minutes of clinical death at normal body temperature is rare. Usually brain damage or later brain death results after longer intervals of clinical death even if the heart is restarted and blood circulation is successfully restored. Brain injury is therefore the chief limiting factor for recovery from clinical death.
Clinical death

Although loss of function is almost immediate, there is no specific duration of clinical death at which the non-functioning brain clearly dies. The most vulnerable cells in the brain, neurons of the hippocampus, are fatally injured by as little as 10 minutes without oxygen. However, the injured cells do not actually die until hours after resuscitation.
Biological death is irreversible condition. Metabolism and functioning of vital organs has completely ceased. Organ damage is as extensive that resuscitation of the body is impossible.

Evident symptoms of the death:
- Rigor mortis
- Death spots on the body
- Drop of body temperature to the level of the surrounding
The obvious signs of biological death are as follow:

- **Paleness of the body (pallor mortis)** begins to develop on the body within 15 - 20 minutes under the effect of the gravitational force, as a result of which the skin and the mucous membranes become pale.

- **Postmortem lividity (livor mortis)** appear. The postmortem lividity appearing in case of death are of imbibitional nature, while sinking postmortem lividity may also develop on a living patient.
The obvious signs of biological death are as follow:

- **Cadaveric rigidity (rigor mortis)** It develops gradually in all the muscular tissues of the body. It begins within 30 minutes in the heart muscle whereas it starts within 2-4 hours in the skeletal muscles where it develops fully in 5-8 hours and then it resolves within 24-48 hours.
- The **cooling down of the body (algor mortis)** to the temperature of the environment always depends on the weather and environmental conditions.
- **Putrefaction (putrefaction), autodigestion (autolysis)** begins under the effect of the bacteria that can be found in the environment.
Biological death

- *Mummification* (mumifiatio) develops in case of extremely dry environment by *exsiccation* (exsiccation).
- *Injuries incompatible to life* often happen as a consequence of serious accidents (e.g. head separated from the body). From the point of view of the functioning of the body, in case of non-professionals, their most important task has been defined as to recognize the threatening stoppage of circulation and/or breathing or the recognition of the patient’s already developed circulatory or respiratory deficiencies during the assessment of the patient’s primary status.
Signs of biological death

- Relative signs of death:
  - passive body’s position
  - pale colour of the skin
  - loss of reflexes and sensority
  - loss of pulse and breathing
  - cooling of extremities
  - Byeloglazov’s sign

Byeloglazov’s sign (cat eye)
While squeezing the eyeball from a deceased pupil becomes oval.
Examples
Cardiac arrest (CA): the cessation of the heart’s mechanical (“pump”) activity. The basic vital functions (breathing and heart activity) have been ceased suddenly but it is biologically HOPEFUL to restore them. In clinical circumstances the diagnosis of CA is established by:

a) unresponsiveness,

b) absence of NORMAL breathing,

c) absence of central pulse/signs of life.

Death: the beginning of irreversible degradation of the organism due to complete cessation of breathing, circulation and cerebral functions and it is biologically HOPELESS to restore them.
Causes of cardiac arrest

A) **Airway obstruction**: blood, vomitus, foreign body, direct trauma, central nervous system depression, laryngeal oedema, bronchial secretions, etc.

B) **Breathing inadequacy**: central nervous system depression, severe chest injury, tension PTX, massive HTX, asthma, pulmonary oedema, ARDS, etc.

C) **Cardiac abnormalities**: myocardial infarction (ACS), hypertensive heart disease, valve disease, cardiomyopathies, electrocution, cardiac tamponade, secondary to hypoxaemia, hypothermia, abnormal electrolyte concentration (K⁺, Ca²⁺, Mg²⁺), etc.
Causes of cardiac arrest

D) Neurological causes: stroke, tumors, infections of CNS, status epilepticus, hydrocephalus

E) Other causes, events: trauma, poisoning, homeostasis disturbances, etc. ...
Diagnosis of cardiac arrest

1) Loss of **consciousness**.

2) Loss of apical & central **pulsations** (carotid, femoral).

3) **Apnea**.
Factors Affecting the Outcome of Resuscitation

Ventricular fibrillation duration

- ischemic changes begin with the onset of the VF
- organ damage becomes irreversible after approximately 4 minutes of VF
- with CPR, survival declines by 10% for each minute without defibrillation; and after more than 12 minutes the survival rate is only 2 - 5%

*Delay in defibrillation reduces survival.* The curves represent the relation of collapse to CPR and defibrillation to survival after a witnessed out-of-hospital cardiac arrest due to ventricular fibrillation. Each curve represents change in probability of survival as delay to defibrillation increases for a given collapse-to-CPR interval (minutes). (Data from Thompson, RJ, McCullough, PA, Kahn, JK, et al, Am J Cardiol 1998; 81:17.)
Cardiopulmonary resuscitation (CPR)

There are 4 cornerstones for optimizing the outcome following cardiac arrest:

- **Early recognition** & call for help: to prevent cardiac arrest.
- **Early CPR** (with **minimal interruptions**): to buy time.
- **Early defibrillation**: to restart the heart.
- **Post resuscitation care**: to restore quality of life & minimize neurological insult.
The chain of survival

Survival rate: 49-75%!
Clinical signs preceding cardiac arrest („alarming symptoms“):

- cold, pale, clammy skin,
- cyanosis,
- suddenly appearing cold perspiration,
- choking,
- breathing problems (shortness of breath, respiratory rate <5/min or >35/min, „gasping“)
- weak or inpalpable pulse,
- pulse rate <40/min or >150/min,
- falling level of consciousness,
- epileptic seizure,
- severe chest pain, extreme abdominal pain or headache.
DNAR /Do Not Attempt Resuscitation/

- signs of biological death (livor mortis, rigor mortis, putrefaction, mummification);

- serious injury which is obviously not consistent with life;

- end-stage of a known, obviously lethal disease (malignancy or any other incurable illness).
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Level of Consciousness

A - Alert
V - Responsive to Verbal stimulus
P - Responsive to Pain
U - Unresponsive
Assessing Consciousness

AVPU and Glasgow Coma Scale
Rapid Assessment

☐ A  Alert

☐ V  responds to Voice

☐ P  responds to Pain

☐ U  Unresponsive
Glasgow Coma Scale

- Assesses patient's neurological condition
- Value range 3 to 15
- 3 totally comatose patient
- 15 fully alert patient
Classification of Brain Injury According to Glasgow Coma Scale (GCS) (HICKEY 2003)

MILD
GCS 13-15

MODERATE
GCS 9-12

SEVERE
GCS 3-8
Neurological chart

- GCS top section
- Temperature/BP/pulse/respiratory rate
- Pupil size / reaction to light
- Limb movement - arms and legs
Eye opening

- Spontaneous = 4
- To speech = 3
- To pain = 2
- None = 1
Verbal response

- Orientated = 5
- Disorientated = 4
- Monosyllabic = 3
- Incomprehensiven = 2
- None = 1
Motor response

- Obeys commands = 6
- Localises pain = 5
- Withdrawal to pain = 4
- Flexion to pain = 3
- Extension to pain = 2
- None = 1
Posturing

A. Extension posturing (decerebrate rigidity)

B. Abnormal flexion (decorticate rigidity)
# Consciousness and impaired consciousness

## Chart 1. Potential causes of long-lasting impaired consciousness

<table>
<thead>
<tr>
<th>The main reasons of long-term impaired consciousness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central nervous system processes</strong></td>
</tr>
<tr>
<td>- serious skull injuries</td>
</tr>
<tr>
<td>- infections of the nervous system</td>
</tr>
<tr>
<td>- circulatory disorders</td>
</tr>
<tr>
<td><strong>Metabolic disorders</strong></td>
</tr>
<tr>
<td>- the change of blood sugar level</td>
</tr>
<tr>
<td>- disorders of the salt and water equilibrium</td>
</tr>
<tr>
<td><strong>Poisoning</strong></td>
</tr>
<tr>
<td>- drugs (LSD, cocaine)</td>
</tr>
<tr>
<td>- medicine</td>
</tr>
<tr>
<td><strong>Accidents</strong></td>
</tr>
<tr>
<td>- drowning</td>
</tr>
<tr>
<td>- electric shock</td>
</tr>
<tr>
<td>- heat damages</td>
</tr>
<tr>
<td><strong>Circulatory and respiratory deficiency</strong></td>
</tr>
<tr>
<td>- heart rhythm disorders</td>
</tr>
<tr>
<td>- pulmonary embolism</td>
</tr>
</tbody>
</table>
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Basic Life Functions
Vital Signs

Breathing
Heart functioning
Circulation
The temperature of the human body
### Chart 1. The degrees of the basic life functions’ parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Degree (adult)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal</td>
</tr>
<tr>
<td>Breathing</td>
<td>14-16/min</td>
</tr>
<tr>
<td></td>
<td>10-15/min</td>
</tr>
<tr>
<td>Pulse</td>
<td>70-80/min</td>
</tr>
<tr>
<td></td>
<td>40-60/min</td>
</tr>
<tr>
<td></td>
<td>60-80/55-60 Hgmm</td>
</tr>
<tr>
<td>Body temperature</td>
<td>36.5-37.2°C</td>
</tr>
<tr>
<td></td>
<td>32-36°C</td>
</tr>
</tbody>
</table>
Respirations

- A patient who is breathing without assistance: *spontaneous respirations*.

- Each complete breath consists of two distinct phases:
  - Inspiration (inhalation): the chest rises up and out, drawing oxygenated air into the lungs
  - Expiration (exhalation): the chest returns to its original position, releasing air with an increased carbon dioxide ($CO_2$) level out of the lungs
Respirations

- **Rate:**
  - The number of breaths in 30 seconds x 2

- **Quality:** character of breathing:
  - Rhythm (regular or irregular)
  - Effort (normal or labored)

- **Depth:**
  - Tidal Volume (the amount of air exchanged with each breath)
    - Depth and rate of breathing determines the tidal volume
Respiratory Rate

Adults: 12 to 20 breaths/minute (over age 8)

Children: 18 to 30 breaths/minute (1 to 8 years of age)

Infants: 30 to 60 breaths/minute (under 1 year of age)
Respirations

- Effort (labored):
  - Unable to speak more than 2-3 words at a time
  - Assuming a “tripod” position
  - Assuming a “sniffing” position (children)
- Noisy breathing:
  - Stridor
  - Wheezes, snoring
  - Coughing (productive?)
Pulse Oximetry

- Evaluates the effectiveness of oxygenation.
- Normal value: 95% - 100%.
Pulse

- With each heartbeat, ventricle contract, forcefully ejecting blood from the heart and propelling it into the arteries.
- A pulse is the pressure wave that occurs as each heartbeat causes a surge in the blood circulating through the arteries.
Pulse

Carotid Pulse

Radial Pulse
Pulse

Brachial Pulse
Pulse

- Rate:
  - Number of beats in 30 seconds x 2

- Strength:
  - Stronger than normal (bounding), strong or weak (thready)

- Regularity:
  - Regular or irregular
Count for 30 seconds
Multiply x 2

Example: 40 x 2 = 80
# Normal Pulse Ranges

<table>
<thead>
<tr>
<th>Group</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>60 to 100 beats/minute</td>
</tr>
<tr>
<td>Children</td>
<td>70 to 120 beats/minute</td>
</tr>
<tr>
<td>Toddlers</td>
<td>90 to 150 beats/minute</td>
</tr>
<tr>
<td>Newborns</td>
<td>120 to 160 beats/minute</td>
</tr>
</tbody>
</table>
The Skin

- The condition of the patient's skin can tell you a lot about the patient's:
  - Peripheral circulation and perfusion
  - Blood oxygen levels
  - Body temperature
The Skin (CCT)

- **Color:**
  - Pink, pale, blue, red, or yellow

- **Condition:** (moisture)
  - Dry, moist or wet

- **Temperature:**
  - Warm, hot or cool
Capillary Refill

- Evaluates the ability of the circulatory system to restore blood to the capillary system (perfusion).
  - Evaluated at the nail bed (finger)
  - Depress the finger tip, pressure forcing blood from the capillaries and look for return of blood
Capillary Refill

- As the capillaries refill, should return to its normal deep pink color
- Color should be restored within 2 seconds (about the time it takes to say, “Capillary refill"
- Invalid test in a cold environment; elderly
- Used for < 6 years old
Blood Pressure

- Blood pressure is a vital sign.
- Pressure of circulating blood against the walls of the arteries.
- A drop in blood pressure may indicate:
  - Loss of blood
  - Loss of vascular tone
  - Cardiac pumping problem
- Blood pressure should be measured in all patients older than 3 years of age.
Blood Pressure

- **Diastolic:**
  - Pressure during relaxing phase of the heart’s cycle

- **Systolic:**
  - Pressure during contraction
  - Measured as millimeters of mercury (mmHg).
  - Recorded as systolic/diastolic.
Auscultation of Blood Pressure

- Place cuff on patient's arm (1" above elbow).
- Palpate brachial artery and place diaphragm of stethoscope over artery.
- Inflate cuff until you no longer hear pulse sounds.
- Continue pumping to increase pressure by an additional 20 mmHg.
Auscultation of Blood Pressure

- Note the systolic and diastolic pressures as you let air escape slowly.
- As soon as pulse sounds stop, open the valve and release the air quickly.
Measuring Blood Pressure

Palpation

Auscultation
Palpation of Blood Pressure

- Secure cuff.
- Locate radial pulse.
- After the pulse disappears continue to inflate another 30mmHg.
- Release air until pulse is felt.
- Method only obtains systolic pressure.
# Normal BP Ranges

<table>
<thead>
<tr>
<th>Age</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>90 to 140 mmHg (s)</td>
</tr>
<tr>
<td></td>
<td>60 to 90 mmHg (d)</td>
</tr>
<tr>
<td>Children (1-8)</td>
<td>80 to 110 mmHg (s)</td>
</tr>
<tr>
<td>Infants (up to 1 yr)</td>
<td>50 to 90 mmHg (s)</td>
</tr>
</tbody>
</table>

*Varies with age and gender.*
Blood Pressure

- **Hypotension:**
  - BP significantly lower than the normal range
  - Critical hypotension: BP is no longer able to compensate sufficiently to maintain adequate perfusion

- **Hypertension:**
  - BP significantly higher than the normal range
Pupil Assessment

- P - Pupils
- E - Equal
- A - And
- R - Round
- R - Regular in size
- L - React to Light
Abnormal Pupil Reactions

- Fixed with no reaction to light.
- Dilate with light and constrict without light.
- React sluggishly.
- Unequal in size.
- Unequal with light or when light is removed.
The vital signs you obtain serve two important functions:

- First set establishes a baseline of respiratory and cardiovascular system status
- Serves as a key baseline
Reassessment of Vital Signs

- Reassess stable patients every 15 minutes.
- Reassess unstable patients every 5 minutes.
- Reassess/record VS after all medical interventions.
First Aid Recruit

- Cellular Phone
- Adhesive Tape
- Tweezers
- Antiseptic Ointment
- Gauze
- Gauze Pads
- Running Shoes
- Emergency Phone Numbers
- Hand Cleaner
- Small Flashlight
- Extra Batteries
- First Aid Kit
- Disposable Gloves
- Band-Aids (assorted sizes)
- Cold Pack
## Basic Life Support Chart

<table>
<thead>
<tr>
<th>D</th>
<th>Danger - Check for danger, risks or hazards. Always ensure the safety of yourself, any bystanders and the casualty</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Response - Check for a response. Is the casualty conscious / unconscious? Call 000 for the ambulance. From a Mobile:112</td>
</tr>
<tr>
<td>A</td>
<td>Airway - Is the Airway open? Look for signs of life. No signs of life will mean the casualty is unconscious, unresponsive, not breathing normally, not moving.</td>
</tr>
<tr>
<td>B</td>
<td>Breathing - Give 2 initial breaths, if not breathing normally.</td>
</tr>
<tr>
<td>C</td>
<td>Compressions - Give 30 chest compressions (At a rate of almost 2 compressions per second) followed by 2 breaths</td>
</tr>
<tr>
<td>D</td>
<td>Defibrillation - Cardiac Arrest Casualties need urgent defibrillation to increase their chance of survival. Continue doing CPR until qualified personnel arrive and take over care of the casualty or until signs of life return. Don’t delay getting help.</td>
</tr>
</tbody>
</table>