1 Last Call for Emergency Medicine

TÜRKİYE CUMHURİYETİ'NİN YÜZÜNCÜ YILI

Editor

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PREFACE

Dear Reader

The world population is increasing day by day. The increasing and aging population brings with it an increase in the demand for health services. Not only in developing countries but also in developed countries, the most frequent deaths occur due to causes requiring emergency intervention. In other words, it is possible to prevent at least some of these deaths with effective emergency interventions. For this reason, emergency medicine has an increasingly important role in the field of health care. This book aims to intervene effectively in preventable emergencies and to improve the knowledge and skills of healthcare professionals to manage critical situations.

Hyperkalaemia is a life-threatening emergency that can occur in the course of many diseases. Our book provides the reader with the latest information on recognizing this serious clinical condition, and managing it with current guidelines, treatment protocols, and care strategies.

Trauma patients are one of the most common and preventable causes of death in emergency medicine practice. Pregnant patients present special challenges that further complicate the situation. Both maternal and fetal health need to be protected and this situation needs to be handled specially. Our book provides up-to-date information on trauma management in pregnant patients, recognizing possible secondary conditions and increasing the ability to provide effective emergency intervention.

The practice of cardiopulmonary resuscitation is improving every year. Cardiopulmonary resuscitation, which is an important part of emergency medicine practice, has a wide perspective from basic skills that every healthcare professional should know to interventions that require special equipment and training. Current information about Double Sequential External Defibrillation, which has been frequently discussed in recent years, is conveyed to the reader in this book.

Electrical injuries are one of the important clinical situations that emergency medicine professionals have to deal with. It should be kept in mind that pathologies related to all organs and systems through which current passes can be observed. Information to guide the approach to electrical injuries is included in this book.

This book provides reliable and up-to-date information to health professionals by addressing the issues related to the science of Emergency Medicine. It will be a resource that will strengthen the knowledge and skills of readers on the aforementioned topics.

Editor

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CHAPTER I

Hypercalemıa In The Emergency Department

Hatice GÜLDAL[1]
Kudret SELKİ[2]

Introduction

Potassium is the most abundant cation in the human body, with 98% located intracellularly and 2% extracellularly (Altay, 2021). Its primary physiological functions include glycogen synthesis and the regulation of cellular metabolism, such as protein, as well as basic acid balance (Watanabe, 2020). The extracellular fluid potassium level is precisely controlled, fluctuating by an average of 0.3mEq/L. Hyperkalemia is defined as a serum potassium level exceeding 5.0 mEq/L. Mild hyperkalemia occurs when the potassium level in the

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blood is between 5.0-6.0 mEq/L, while moderate hyperkalemia is present between 6.0-7.0 mEq/L. Severe hyperkalemia is diagnosed when the potassium level in the blood surpasses 7.0 mEq/L(Palmer et al., 2021).

A rise in plasma potassium levels by 3-4 mmol/L can trigger arrhythmias, while higher levels of potassium can lead to cardiac fibrillation and arrest. Hyperkalemia requires urgent medical attention due to the potential for fatal dysrhythmias resulting from cardiac membrane instability (Lemoine et al., 2021). Indications of hyperkalemia include cardiac dysfunction, such as muscle weakness, paralysis, and arrhythmia, which can pose a risk to life (Davis et al., 2021).

Daily intake of potassium typically ranges from 50-200mEq/day, necessitating rapid removal of excess from extracellular fluid. Impaired mechanisms for excretion of potassium into the cell can cause life-threatening hyperkalemia.

The ion is eliminated via the gastrointestinal tract, kidneys and skin. Normally, potassium is excreted in the body via diverse routes: approximately 5 mEq/day through sweating, 5 to 10 mEq/day through faeces, and 92 mEq/day through urine (Watanabe, 2020). Mostly, the kidneys are responsible for the excretion of potassium with 90-95% being excreted through the kidneys while 5-10% is excreted via the colon. In cases of renal dysfunction, there is an increase in colonic excretion. Although kidneys effectively regulate potassium hemostasis in the long term, skeletal muscles are involved in the short-term maintenance of potassium hemostasis (Altay, 2021).

Mechanisms of Potassium Distribution

a) Insulin increases potassium uptake into cells after meals.

b) Aldosterone increases potassium uptake into cells. Excessive secretion causes Conn's syndrome with hypokalemia, and deficiency causes Addison's disease with hyperkalemia.

c) ß-Adrenergic stimulation also increases potassium uptake into cells.

d) Metabolic acidosis leads to potassium loss from cells.

e) Metabolic alkalosis decreases the concentration of potassium in the extracellular fluid.

f) The extracellular space experiences an increase in intracellular potassium during severe tissue damage.

g) Skeletal muscle releases potassium into the extracellular fluid during prolonged exercise and severe muscle damage.

h) Increased osmolality of extracellular fluid causes a shift of potassium from cells to the extracellular fluid.

Etiological Factors

Hyperkalemia is a rare occurrence in the general populace, and its precise incidence is uncertain due to infrequent monitoring of potassium levels and the transient nature of elevated potassium. Hospital-based studies conducted across various countries have emphasized the importance of measuring potassium at regular intervals. The lack of appropriate patient follow-up in even the highest-risk cases implies a global prevalence of hyperkalemia that surpasses original estimates (Palmer et al., 2021).

Risk factors for hyperkalemia vary depending on comorbidities and diet. Individuals with chronic kidney disease (CKD) are at a heightened risk. Conditions such as diabetes mellitus (DM), heart failure, systemic lupus erythematosus, sickle cell anemia, kidney transplantation, type IV renal tubular acidosis, acute kidney injury, patients requiring blood transfusions, gastrointestinal bleeding, hyponatremia, hypoaldosteronism, and old age increase the risk of hyperkalemia.

Certain drugs, including cardiac glycosides, β2-adrenergic receptor blockers, renin-angiotensin-aldosterone system (RAAS) inhibitors, nonsteroidal anti-inflammatory drugs (NSAIDs), angiotensin converting enzyme inhibitors, cyclosporine, tacrolimus, and heparin, can induce a rise in potassium levels.

Hyperkalemia may also occur due to several other factors, such as tourniquet use, hemolysis, heavy exercise, acidosis, potassium supplements, rhabdomyolysis, extensive tissue necrosis, and cell destruction following chemotherapy.

Clinical Symptoms

a) Weakness, fatigue

b) Decreased reflexes, parasthesia, paralysis

c) Muscle weakness (starting from the legs and progressing to the arms and trunk, mimicking Gullian-Barre syndrome)

d) Nausea, vomiting, diarrhea

e) Cardiac dysrhythmias (complete heart block, ventricular fibrillation, atrioventricular blocks)

f) Diastolic arrest

Electrocardiogram (ECG) Changes

a) Prolonged PR interval

b) Long-pointed T waves

c) Short QT interval

d) Flattening of the P wave

e) QRS widening

f) Conversion of the QRS complex into a sinusoidal pattern

g) Right-left bundle branch blocks

h) Bifascicular and complete AV block

i) Ventricular tachycardia

j) Ventricular fibrillation

ECG findings and potassium level do not show a complete correlation, so potassium monitoring with ECG is not recommended.

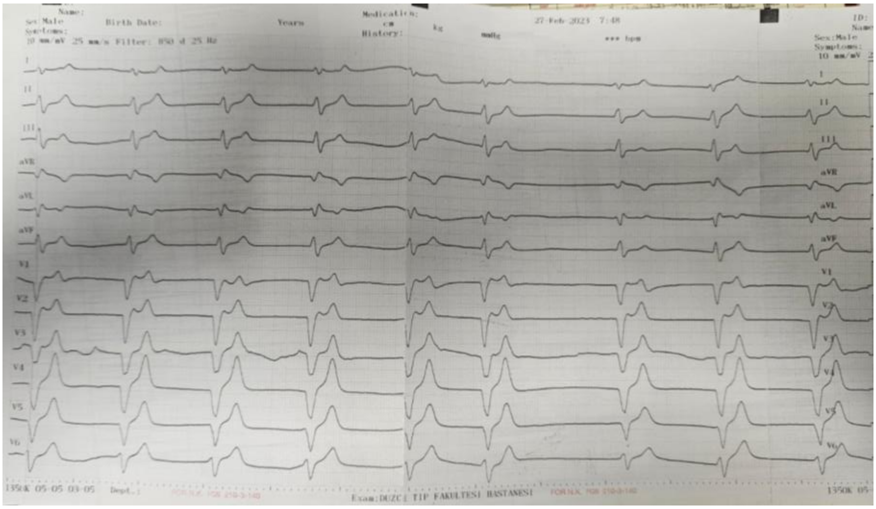

Figure-1

The electrocardiogram shown in Figure 1 belongs to a 67-year-old woman who was admitted to the emergency department due to decreased consciousness and low pulse rate. She has a history of chronic kidney disease, diabetes mellitus, and hypertension. The test results indicate blood gas pH of 7.25, potassium level of 7.7 mEq/L, and creatinine concentration of 6.86 mg/dL in both serum and plasma. The patient underwent initial intervention in the emergency department and was subsequently referred to the dialysis unit.

Treatment

Hyperkalemia is a condition that requires urgent intervention and should be treated at home in patients with risk factors for increased potassium, such as patients with CKD. Emergency treatment can be divided into three methods according to their mechanism of action.

a) Membrane stabilization

b) Potassium uptake into the cell

c) Removal of potassium from the body

A)Membrane stabilization

Calcium chloride and calcium gluconate are administered to stabilize the cell membrane. Calcium increases the excitability of myocytes, which helps stabilize the heart and protect it against arrhythmias. Potassium regulation is not affected by calcium. The optimal dosage of calcium gluconate and calcium chloride for use remains unclear. Due to the irritant properties of calcium on veins, it is recommended to dilute it in dextrose and administer it through a central vein, if possible. In cases of hyperkalemia resulting from digoxin toxicity, calcium is contraindicated due to its sodium-potassium ATPase inhibiting properties. Overdose commonly leads to hyperkalemia, and while intravenous calcium is often utilized to treat the condition, it has been traditionally considered contraindicated in the context of digoxin toxicity (Levine et al., 2011).

B)Potassium uptake into the cell

a) Insulin causes potassium to enter the cell by activation of Na-K ATPase pump and causes membrane hyperpolarization by binding to its receptor. The most important side effect is hypoglycemia. Monitoring and close fingertip blood glucose monitoring is required. 5-10 units of regular insulin can be administered intravenously (IV) with 25 grams of glucose. The insulin dose can be determined according to the patient's blood glucose level or the presence or absence of renal failure. In studies conducted at different times, the risk of hypoglycemia and the efficacy of high-dose (10 units) insulin and low-dose (5 units or 0.1units/kg) insulin in potassium lowering were investigated, and as expected, high-dose insulin increased the risk of hypoglycemia. On the other hand, when the two insulin treatments were compared, no significant difference was found between their potassium-lowering efficacy (Keeney et al., 2020; Moussavi et al., 2019).

b) Catecholamines increase the activity of the Na-K-ATPase pump and Na-K-2Cl co-transporter, thereby redistributing potassium. Nebulized albuterol is administered in doses of 20 mg for hyperkalemia.

c) Sodium bicarbonate may help potassium to enter the cell through hydrogen and potassium exchange. However, routine administration of sodium bicarbonate is not recommended unless the patient has concomitant metabolic acidosis. Despite its routine use in the clinical setting, the efficacy of sodium bicarbonate in acute hyperkalemia has not been fully established (Geng et al., 2021). The important thing in treatment is to correct the underlying cause of acid-base imbalance.

C)Removal of Potassium from the Body

a) Furosemide is given between 40-80 mg IV and provides renal excretion of potassium, although the onset and duration of action are variable.

b) Sodium polystyrene sulfonate is an oral drug that provides potassium excretion from the gastrointestinal tract but is associated with intestinal necrosis (Harel et al., 2013).

c) Two new oral binding agents, patiromer and sodium zirconium cyclosilicate, have been shown to be useful in lowering potassium levels in patients with mild hyperkalemia; however, the onset of action of patiromer is too slow to be useful in life-threatening hyperkalemia. Patiromer is a calcium-sorbitol ion-containing potassium exchange resin that is not absorbed from the intestine (Meaney et al., 2017; Shibata & Uchida, 2022). Patiromer binds potassium in the colon and decreases serum potassium levels within 6-8 hours (Palmer et al., 2021; Shibata & Uchida, 2022). Side effects of patiromer include magnesium depletion and associated gastrointestinal symptoms such as diarrhea, nausea and vomiting, and constipation.

Dialysis

Dialysis is the most effective method to remove potassium from the body. Indications for dialysis include severe and life-threatening hyperkalemia (with or without ECG changes or arrhythmias), hyperkalemia refractory to medical therapy, end-stage renal disease, oliguric acute renal injury (AKI) (<400 mL/day urine output), severe tissue destruction (e.g. rhabdomyolysis).

Achieving appropriate K+ concentrations on dialysis is critical because dialysis-induced K+ decline can trigger arrhythmias and cardiac death. In addition to the potential risk of death from hyperkalemia, patients receiving hemodialysis may have an increased risk of death from other factors such as fluid overload (Palmer, 2020).

During dialysis treatment, serum potassium levels usually decrease by 1 mmol/L within the first hour, followed by another 1 mmol/L decrease within the next 2 hours, and gradually declining towards the dialysate potassium concentration in the later hours (Shibata & Uchida, 2022). Although excess potassium accumulated in the body must be effectively removed, abrupt changes in serum potassium levels and severe hypokalemia following dialysis may negatively impact mortality (Karnik et al., 2001; Ohnishi et al., 2019).

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CHAPTER II

Trauma Management During Pregnancy

Kudret SELKİ[1]

Introduction

Pregnancy trauma is a difficult situation in which both the mother and the fetus are affected, and the physician must manage both traumas simultaneously. Therefore, trauma management in pregnant women requires a multidisciplinary approach. It is essential to be well aware of pregnancy-specific conditions such as radiation dose, teratogenicity of the drug to be administered, and the need for Rh immunization.

3% of patients who visit the emergency department with trauma are pregnant. 11% of pregnant women do not know they are pregnant, so every woman of childbearing age should be treated as if she is pregnant until proven otherwise (Bochicchio et al., 2001).

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Trauma is the number one (20%) cause of non-obstetric maternal deaths (Kuhlmann & Cruikshank, 1994). There is also a 40-50% risk of fetal death in pregnant women with major trauma (Oxford & Ludmir, 2009). Even with minor trauma, there is an increased risk of premature or low birth weight childbirth if it occurs in the first or second trimester (El Kady et al., 2004).

Anatomical and Physiological Effects of Pregnancy

Anatomical Effects

As the uterus grows, the uterine wall becomes thinner, and the intestines are pushed upwards. The placenta hardens as pregnancy progresses(Murray & Hendley, 2020). The uterus rises above the symphysis pubis between 8-12 weeks. It reaches the belly level by 20-22 weeks. In the 36th week, the height of the uterus reaches the sternum, and it lowers slightly as the fetal head settles into the pelvis . In short, the uterus is located intrapelvic until the 12th week of pregnancy. It rises to the umbilicus level in the 20th week and reaches its highest level in the 36th week (Beazley & Underhill, 1970).

Cardiovascular System Changes

It is expected to increase 10-15 beats/min in the pulse at rest during pregnancy. In the first two trimesters, SBP decreases by 10-15 mmHg, and DBP decreases by 10-20 mmHg. Excessive hypotension and related symptoms may occur in pregnant women in the supine position. This condition is called supine hypotension syndrome.(Kinsella & Lohmann, 1994)

Therefore, pregnant women should be placed in the left lateral decubitus position to reduce the pressure on the inferior vena cava and increase cardiac output. In the 3rd trimester, peripheral vascular resistance decreases, and they approach the normotensive state.(Marques et al., 2015)

The signs of hypovolemia may go unnoticed until approximately 30% of blood volume (1200-1500 ml) is lost. Indicators of fetal distress, such as abnormal fetal cardiac movements, may serve as initial manifestations of maternal bleeding. Therefore, early volume replacement in cases of maternal hemorrhage is crucial for fetal well-being.

Respiratory System Changes

With the enlargement of the uterus, the diaphragm rises approximately 4-5 cm, and in response, the thorax attempts to preserve lung volume through an increase in diameter(LoMauro & Aliverti, 2022).

It is crucial to be aware of this when performing tube thoracostomy. Chest tubes should be placed along the mid-axillary line, but positioned 2 cm higher to prevent potential puncture of the liver or spleen (Mitsunari et al., 2008).

The expansion of the lower thoracic cage, the widening of abdominal muscles, and the maintenance of the diaphragm's normal function during pregnancy generally result in unaltered vital capacity and total lung capacity. However, total lung capacity may exhibit a slight decrease in the third trimester. These mechanisms lead to the normal hyperventilation of pregnancy, causing mild respiratory alkalosis with compensatory metabolic acidosis. As mentioned earlier, pregnant individuals undergo hyperventilation during pregnancy, labor, and delivery. Renal excretion of bicarbonate is increased to maintain the pH between 7.40 and 7.45. Consequently, the serum HCO_3 level is kept between 18 and 21 mEq/L (with a base deficit of 3-4 mEq/L).

In pregnancy, the enlargement of the soft palate, a feature influencing airway patency, leads to an increased Mallampati Score, which is used to assess airway adequacy (Pilkington et al., 1995).

Gastrointestinal System Changes

In pregnancy, lower esophageal tone decreases along with reduced gastric motility and secretion. The gastroesophageal junction shifts slightly upward. In trauma patients, this condition can lead to gastric distension, increased reflux, and an elevated risk of aspiration (Longo et al., 2010).

Urinary System Changes

Glomerular Filtration Rate (GFR) and renal blood flow increase by 50%. This results in a 50% reduction in blood creatinine and Blood Urea Nitrogen (BUN) levels. Dilation is observed in the renal pelvis and calyces(Waltzer, 1981).

Hematological Changes

Both plasma volume and erythrocyte mass increase during pregnancy. Plasma volume doubles by the end of the third trimester, but it develops at a much higher rate than the increase in red blood cell mass. This condition leads to dilutional anemia in pregnancy. Normal hemoglobin is 10-14 grams per deciliter depending on the term. The liver becomes hypermetabolic, increasing the production of coagulation factors and fibrinogen, resulting in a state of hypercoagulability(Paidas & Hossain, 2010).

Pregnant patients are at a higher risk for deep vein thrombosis and disseminated intravascular coagulation (DIC). DIC panels should be interpreted with caution(Paidas & Hossain, 2010).

Etiology

The etiology of trauma during pregnancy can be multifactorial. The expanding abdomen may increase the frequency of falls from heights, such as when the mother is standing or descending stairs, leading to instability. The normal physiology of a pregnant woman complicates the assessment and management of trauma during pregnancy. The pregnant uterus, in particular, is sensitive to both penetrating and blunt force traumas directed at the abdomen.

Motor vehicle accidents account for 50% of all traumatic injuries during pregnancy and contribute to 82% of trauma-related fetal deaths. The primary cause of this is the improper use of seat belts. During a motor vehicle collision, for reducing pressure on the uterus, the seat belt should be positioned as a 3-point restraint, placed below the horizontal plane of the abdominal dome (under the uterine corpus) and across the pelvis. The shoulder strap is recommended to be positioned along the clavicle and passing between the breasts, ensuring it is not overly tight (Klinich et al., 2008; Mattox & Goetzl, 2005).

Fetal and Maternal Injury Mechanisms

Mortality in pregnant trauma patients is most commonly associated with head injuries and hemorrhagic shock. While minor traumas may not lead to maternal losses, they are significant in terms of fetal outcomes.

Blunt Abdominal Traumas~~(Pearlman et al., 1990)~~

• Motor vehicle accidents, falls, and abdominal injuries, such as blunt force trauma, are the most commonly encountered.

• Fetal deaths in the first trimester may be secondary to uterine hypoperfusion. Fetal mortality is observed in less than 1% of cases. Effects of trauma may become evident weeks after the incident.

• In the second and third trimesters, fetal deaths are more likely to occur due to placental disruption or direct fetal injury.

• Symptoms may include vaginal bleeding, abdominal and back pain, uterine tenderness, shivering, fetal distress, fetal bradycardia, and signs of maternal DIC as a response to placental separation (Pearlman et al., 1990).

Penetrating Traumas~~(Shah & Kilcline, 2003)~~

• Especially in the second and third trimesters, maternal deaths are observed to be 30% less compared to the general population, attributed to the upward displacement and buffering function of the uterus on the intestines and other organs.

• In penetrating traumas, the fetal mortality rate reaches around 60%.

• If maternal stability can be achieved through maternal laparotomy, cesarean section is not a routine indication.

• In cases where uteroplacental flow is compromised due to obstetric reasons such as uterine artery injury, cesarean section should be performed (Shah & Kilcline, 2003).

First Examination

First and foremost, a determination should be made regarding the patient's needs from the perspective of ABC (Airway, Breathing, Circulation). If the pregnancy is beyond 24 weeks, the patient is placed in the left lateral position. Fetal heart rate is assessed, and following maternal stabilization, the earliest possible fetal monitoring and obstetric evaluation are provided.

Airway

While paying attention to cervical spine injury, the risk of aspiration should be considered, and early intubation should be performed if necessary. If cervical injury is present, intubation can be carried out using fiberoptic laryngoscopy. The challenge of intubation in pregnant women should be kept in mind, and an endotracheal tube with a diameter 0.5-1 mm smaller than usual should be used (Munnur et al., 2005).

Respiration

Deformities should be observed during chest wall inspection. In pregnant women with respiratory problems and thoracic trauma, it should be kept in mind that in addition to rib fractures, conditions such as pneumothorax, chylothorax, hemothorax, tension pneumothorax, and pulmonary collapse may occur.

Circulation

A rapid assessment of the abdomen, chest, pelvis, and thighs should be conducted, and peripheral bleeding should be immediately stopped with direct pressure. Reduction of long bone fractures should be performed to achieve hemorrhage control. Evaluation for hypovolemia should consider tachycardia, a decrease in pulse and jugular vein distension, pallor, and prolonged capillary refill as indicators of shock. If the radial pulse is absent, a systolic blood pressure of approximately 80 mmHg can be assumed (Mandala & Osol, 2012). When the need for defibrillation arises, the voltages are the same as in non-pregnant individuals. There is currently no updated information indicating harm to the fetus. During CPR, if necessary, hands should be placed higher than usual. CPR should not be interrupted for medication administration, and if done, the upper extremities should be preferred since the lower extremities are under compression.(Farinelli & Hameed, 2012) The femoral pulse under uterine pressure is not reliable for monitoring maternal heart rate. Peripheral intravenous catheters, short and wide (at least two and 14/16 gauge), should be maintained to facilitate rapid fluid infusion. Arterial catheterization aids in continuous blood pressure measurement, monitoring bicarbonate and lactate levels, and assessing response to resuscitation. Crystalloid fluids are preferred for fluid replacement, and if hypovolemia persists despite 2-3 liters, consideration should be given to blood transfusion. Urinary catheterization provides information about urine output and urinary tract injuries. Upon correction of hypovolemia, lactate levels should be monitored to ensure tissue oxygenation and efforts should be made to keep them below 1.5 mEq/L(Morris & Stacey, 2003).

In a pregnant patient not responding to resuscitation, considerations should include neurogenic shock, hypothermia, cardiac tamponade, tension pneumothorax, electrolyte and acid-base imbalance, hypoxia, placental abruption that could lead to ongoing shock, inadequate volume replacement, amniotic fluid embolism, and air embolism. For pregnant individuals beyond 23 weeks, if external massage is unsuccessful, immediate cesarean section is performed, and external massage is continued(El Ayadi et al., 2016; Morris & Stacey, 2003).

Neurological

A rapid neurological assessment is conducted, examining orientation and pupil responses. The patient's condition is determined according to the Glasgow Coma Scale.

Second Examination

After the ABCDE assessment and stabilization are performed sequentially, a non-obstetric examination of the mother, further investigations and imaging, obstetric examination, and rectal and vaginal examinations are necessary. Feto-maternal hemorrhage, preterm labor, placental abruption, and membrane rupture should be carefully evaluated. In speculum examination, cervical and vaginal lacerations, hematomas, amniorexis, bleeding, and prolapse of fetal appendages should be investigated. A fetus approaching the viability limit is meticulously assessed through monitoring, and the best approach is determined.

Radiation

The unit "rad" used here is a unit of measure for radiation dose. One millirad (mrad) is one-thousandth of a rad. Nowadays, the gray (Gy) unit is more commonly preferred for radiation dose (1 Gy = 100 rad) (1 cGy = 1 rad).(Timins, 2001)

1 mSv = 1 mGy = 0.1 rad = 100 mrad(Timins, 2001).

The most sensitive period to radiation for the embryo is the first trimester. Due to organogenesis occurring between weeks 2-8, radiation exposure during this period can lead to growth retardation, teratogenic, and postnatal carcinogenic effects. Between weeks 8-40 of pregnancy, teratogenic effects decrease, while postnatal neoplastic effects, growth retardation, and particularly functional abnormalities in the central nervous system may develop. To protect from these effects, the acceptable cumulative radiation dose is 5 rad. Typically, the embryo receives a dose less than 5 rad from radiological procedures. Exposure at this level does not significantly increase the risks of congenital anomalies. Information obtained from medical documents indicates that doses exceeding 20 rad are associated with an increased risk of congenital anomalies and miscarriage. The American College of Radiology (ACR) has stated that a single diagnostic X-ray exposure does not result in adverse effects on the fetus and embryo. The limit for the total radiation dose that could be harmful to the fetus is reported to be 5 rad (50 mGy). Pregnant women working with radiation are allowed a maximum dose of 5 mrad throughout their entire pregnancy. For radiation workers planning to have children, the annual cumulative dose limit is 2-3 rad. After learning about the pregnancy, the most suitable approach is to work outside areas with radiation exposure(McCollough et al., 2007; Patel et al., 2007; Wagner et al., 1997).

Ultrasonography

In pregnancy, it is the most reliable radiological investigation. The presence of free fluid in the abdominal cavity can be detected. It reveals intraperitoneal bleeding after blunt trauma, with specific attention to areas such as the hepatorenal space (Morrison's pouch), the splenorenal space, and the Douglas pouch. If a comprehensive examination, including the pericardium, is performed, it is called a FAST exam (Focused Assessment with Sonography for Trauma). Additionally, ultrasound provides information about fetal status, gestational age, amniotic fluid, fetal movements, and fetal presentation. Fetal fractures and retroplacental hematomas can be detected. However, placental abruption can still be missed in 50-80% of cases. In situations where ultrasound is insufficient, such as detecting pelvic fractures and pelvic organ injuries, MR or CT can be performed(Brown et al., 2005; Henderson & Mallon, 1998).

Magnetic Resonance Imaging(MRI)

MRI is a widely used imaging method, especially for brain, spinal cord injuries, and ligament damage, without the use of ionizing radiation. However, its utility in emergency situations is more limited due to the extended duration of the imaging procedures(Odedra et al., 2023).

Laboratory~~(Abbassi-Ghanavati et al., 2009)(Table-1)~~

• Blood type

• Complete blood count

• Comprehensive biochemical panel including electrolytes and glucose values provides information about metabolic status.

• Coagulation panel

• Levels of fibrinogen and D-dimer

• Evaluation of Kleihauer-Betke test for detecting fetal hemorrhage.

• Arterial blood gas analysis provides information about fetal perfusion.

During this assessment, pregnancy-related values should be taken into consideration (Abbassi-Ghanavati et al., 2009)(Table-1).

Laboratory Findings in Pregnant and Non-Pregnant Women(Abbassi-Ghanavati et al., 2009)		
	Pregnant	Non-Pregnant
Hematocrit	%32-42	%36-57
White blood cell(WBC)	5000-12000 µL	4,000–10,000 µL
Arterial pH	7.40–7.45	7.35–7.45
Bicarbonate	17–22 mEq/L	22–28 mEq/L
PaCO2 (Partial Pressure of Carbon Dioxide	25–30 mm Hg	30–40 mm Hg
PaO2 (Partial Pressure of Oxygen)	100–108 mm Hg	95–100 mm Hg
Fibrinogen	400-450 mg/dL	150-400 mg/dL

Table-1

Consultation

Fetal Approach:

If the gestational age is below the viability limit (approximately 22 weeks), it is sufficient to determine only the presence of the fetal heartbeat. As the fetal weeks progress, the fetus must be closely monitored after stabilizing the mother. To monitor, the following can be employed:

- NST (Non-Stress Test)
- CST (Contraction Stress Test)
- Biophysical scoring can be used.

Thus, the fetus remains continuously monitored under the tracking of heart rate and uterine contractions. Increased uterine activity is common after trauma, but it can also be a sign of preterm birth or placental detachment. Such a situation may also be indicative of an infection that appears several days after the injury. Any uterine contractions or tenderness, abdominal pain, or cramping should be followed closely (Mirza et al., 2010).

Signs of fetal distress predominantly include:(Shah et al., 1998)

• Bradycardia, less than 110 beats/min,

• Tachycardia, exceeding 170 beats/min, often observed when the mother has a fever,

• Loss of beat-to-beat variability,

• Late deceleration of fetal heart rate in response to uterine contractions.

Fetal monitoring is highly valuable in predicting potential placental abruption in the future. While the duration of monitoring remains controversial, it can vary between 4 to 48 hours.

As a result of conducted studies, a 4-hour monitoring is appropriate if the following criteria are met:(Huls & Detlefs, 2018; Jain et al., 2015)

• Uterine contraction frequency is less than 1 in 10 minutes,

• There is no vaginal bleeding,

• The mother is not experiencing pain,

• Maternal stability has been achieved.

In the following cases, at least 24 hours of monitoring is necessary:(Huls & Detlefs, 2018; Jain et al., 2015)

• Those with abdominal injuries,

• Those with more than 1 contraction in 10 minutes,

• Patients with vaginal bleeding,

• Those with abnormalities detected in fetal heart rate,

• Those experiencing abdominal or pelvic pain,

• Those identified with coagulopathy.

Placental detachment can manifest even 5 days after trauma. Therefore, patients with symptoms should be monitored for a longer duration.

Postmortem Cesarean Section ~~(Decision to Deliver)(Guven et al., 2012)~~

There are two important purposes for making the decision for an emergency cesarean section:

•It may be aimed at saving the life of the fetus when the mother has died. If a cesarean section is to be performed based on fetal indications, the gestational age should be determined in advance.

•If effective cardiopulmonary resuscitation cannot be performed to save the mother's life.

If the mother has not developed coagulopathy due to placental abruption, a cesarean section is not performed solely to empty the uterine cavity in the presence of a dead fetus. The cesarean section operation also provides the surgeon with the opportunity to see and treat injured pelvic and abdominal organs (Decision to Deliver)(Guven et al., 2012).

Who is Eligible for Postmortem Cesarean Section?~~(Guven et al., 2012)~~

• In pregnancies beyond 23 weeks, or when the week is unknown, if the height of the uterine fundus is two or more fingerbreadths above the umbilicus,

• Emergency cesarean section should be considered when maternal pulse cannot be obtained instead of prolonged resuscitation.

• Cesarean section should be initiated within 4 minutes after maternal pulse cannot be obtained. (ATLS 10 III-B) (Guven et al., 2012).

Prehospital Approach~~(Jain et al., 2015)~~

• As in non-pregnant patients, ABC assessment should be conducted first.

• Once airway safety is ensured, and if there is normal respiration and circulation, spinal injury should be assessed.

• Pregnant women in the second and third trimesters without spinal injury should be transported in the left lateral decubitus position (if spinal injury is suspected, they should be immobilized and transported in a 15-degree lateral position).

• Oxygen support should be provided to maintain SPO2 > 95%.

• Two large-lumen intravenous lines should be established, and fluid support should be initiated.

• Information regarding the mechanism of injury, initial vital signs, gestational age, time of the last meal, allergies, and relevant medical history should be documented.

• Transportation to the nearest center where maternal and neonatal care can be provided should be planned as soon as possible (Jain et al., 2015).

Emergency Department Approach~~(Jain et al., 2015)~~

• Regardless of the mechanism, trauma can be life-threatening for both the mother and the fetus. Since maternal shock is associated with an 80% fetal mortality rate, rapid evaluation and treatment of the mother should be further emphasized in trauma cases.

• When evaluating a pregnant patient who has experienced trauma, the standard trauma algorithm (ATLS) should be followed. Trauma assessment and resuscitation priorities are the same as in non-pregnant women. Planning for primary and secondary care for the trauma patient should be done appropriately.

• Vital signs that change throughout normal pregnancy, as previously described, should be carefully considered.

• All women of childbearing age who have experienced trauma, regardless of the mechanism, should have a Beta-human chorionic gonadotropin (BHCG) test ordered unless pregnancy is explicitly ruled out.

• A history of preterm birth, placental detachment, and placenta previa should be questioned.

• The evaluation of the pregnant patient should be performed through teamwork involving an emergency medicine specialist, an obstetrician-gynecologist, a neonatologist, and a nurse trained in this field.

• In major trauma patients who are pregnant, the evaluation, stabilization, and care of the mother take precedence. After stabilizing the mother, consultation with obstetrics should be sought.

• If the gestational age is ≥23 weeks, the fetal heart rate should be assessed and monitored in consultation with obstetrics. Atypical and abnormal fetal heart rates may be indicative of fetal hypoxic injury or death, as well as the initial signs of bleeding-related maternal hypovolemia.

• When evaluating pregnant patients, it is important to remember that heart rate increases by 15% compared to normal individuals. Tachycardia and hypotension, typical signs of hypovolemic shock, may be delayed in onset due to increased blood volume in pregnant women.

• In pregnant trauma patients, signs of peritoneal irritation in abdominal examination are less reliable. The abdomen should be palpated to determine the height and firmness of the uterus (if uterine rupture is suspected). In cases of inconsistency between fundal height and gestational age, further investigation for uterine trauma is necessary. In pregnant trauma patients ≥23 weeks, emergency obstetric consultation is necessary in the presence of uterine contractions, placental abruption, or suspicion of uterine rupture.

• Fetal heartbeats can be auscultated with a stethoscope after the 20th week of pregnancy, and before that, Doppler is necessary. Fetal heartbeats can be detected from the 12th week of pregnancy onwards and are normally between 110 and 160 beats per minute (bpm). Fetal distress initially manifests as tachycardia, but as the arterial oxygen content decreases, the fetus eventually becomes bradycardic. Therefore, heartbeats below 120 bpm should be considered as fetal distress. If fetal distress is detected, suspicion of maternal blood loss should be considered.

• Vaginal examination should be performed to assess cervical dilation, effacement, and fetal presentation. In pregnant patients with trauma ≥23 weeks, speculum or digital vaginal examination in the presence of vaginal bleeding should be postponed until placenta previa is ruled out with ultrasound. If hemodynamically feasible, a pelvic examination should be performed with a speculum.

• Vaginal bleeding before delivery is abnormal and may be a sign of placental abruption, preterm birth, early cervical dilation, or placenta previa.

• Suspect ruptured amniotic membranes when there is a cloudy, white, or green discharge, which increases the risk of infection (Jain et al., 2015).

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CHAPTER III

Double Sequential External Defibrillation

İlter AĞAÇKIRAN[1]

Introduction

Double sequential external defibrillation (DSED) is the shocking of the patient with two defibrillators used in refractory ventricular fibrillation (RVF). Refractory ventricular fibrillation is the persistence of 3 or more ventricular fibrillations in a patient with cardiac arrest. Two defibrillators are required. The first of the defibrillator pads can be connected anterolaterally, the second can be connected anterior-posterior or lateral-lateral. However, connecting the second defibrillator anteriorly and posteriorly is the more commonly used method. Defibrillators should be prepared as 200 Joules and defibrillation should be done with two defibrillators at the same time. But this is impossible to implement. Therefore, the time between defibrillation procedures should be minimal.

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When we look at the purpose of this application, it is necessary to affect more myocytes in the patient to terminate refractory ventricular fibrillation. We can predict that DSED provides this with three theories.

Power theory; When we increase the power, we affect more myocytes. While the maximum power we can output with a single defibrillator varies depending on the defibrillator, it is generally 270 Joules. When we use two defibrillators, this power increases to 400 Joules.

Vector theory; While the effect occurs by creating vectors between the two pads; Since there will be four pads here, the myocyte effect can be increased with more vectors on the heart.

Setting up theory; It is thought that the threshold value of myocytes formed after the first defibrillation decreases and more myocytes are taken under control during the second defibrillation with the second defibrillator.

Equipment

Two defibrillators

Two sets of defibrillator pads

Preparation and Technique

After the second shock is administered to the patient, the second defibrillator should be brought and pads should be prepared. During the next shock, the second defibrillator pads should be attached to the patient quickly, with minimal interruption to cardiac compression. There should be no delay between shocking defibrillators.

Position of Pads

The pads of the first defibrillator are classically placed anterolaterally. The first pad is placed under the clavicle bone on the right side of the sternum. The second pad is placed more laterally and lower under the left nipple.

The second defibrillator can be placed anterior-posterior or lateral-lateral, as we mentioned before. However, anterior-posterior placement is more convenient and effective. The first pad is placed in front, under the nipple, between it and the sternum. The second pad is placed under the scapula to the left of the spine. Laterally, it is placed in the right and left axillary region at the level of both nipples.

Clinical significance

In recent studies, DSED has been shown to be more effective in return of spontaneous circulation (ROSC) and neurological outcome.

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CHAPTER IV

Electrıcal Injurıes

Merve AĞAÇKIRAN[1]

Introduction

Although electricity is necessary for our lives, electric shock is a type of trauma that carries high morbidity and mortality and all age groups are at risk. (Karadaş, S. 2011) These are injuries that occur after exposure to a low or high voltage electric current. In addition to electrical injuries, there will also be an increase in temperature in the relevant area, which may also cause thermal injuries. This means that the severity of the injury may vary from the tip of the iceberg.

Electrical injuries are generally occupational, and the number of people injured by home electricity is also quite high. Electricians, power line workers, tree and roof workers, construction workers, and

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crane operators are risky groups for injuries caused by high voltage. Injuries caused by electric current above 1000 volts are considered high voltage, while injuries below 1000 volts are considered low voltage.

Injuries caused by electricity can occur through 3 mechanisms;

1) Direct tissue damage caused by electricity

2) Tissue damage caused by the thermal energy of electricity

3) Mechanical injury caused by a fall or muscle contraction (Fish, 2013)

Clinical Features in Electrical Injuries

Cardiac Involvement

In electrical injuries, cardiac rhythm disorders may be observed along with sudden electrical conduction. It can occur in conditions ranging from asystole, ventricular fibrillation, atrial fibrillation and arrhythmias. Generally, in low-voltage injuries, long-term cardiac monitoring is not required in asymptomatic patients with no electrocardiographic changes upon arrival at the hospital. However, considering that myocardial damage may develop in high voltage injuries, it is important to monitor creatine kinase and troponin values as well as arrhythmia.

Nervous System Involvement

Various effects on the nervous system are observed in electrical injuries. Patients may present with progressive symptoms such as peripheral nerve damage, spinal cord injury, brain damage, seizures and various neurological disorders. They may present with symptoms such as headache, dizziness, loss of coordination, amnesia, agitation, seizure, aphasia, blurred vision, sensory loss, and paresthesia. In those presenting with these complaints, computed tomography (CT), magnetic resonance (MR), electroencephalography (EEG) and electromyography (EMG) are diagnostically helpful. Nervous system pathologies can be reversible or fatal.

Influence of Other Systems

Although the most significant and fatal effects of electrical injuries are on the nervous system and cardiac system, they can also have significant effects on other organs and systems.

While from a dermatological perspective, most skin burns require hospitalization and detailed follow-up by burn specialists, from an orthopedic perspective, fractures, dislocations, movement restrictions, and compartment syndrome may occur in traumas resulting from contractions due to electric shock.

Aneurysms, platelet dysfunction and coagulation disorders can be observed in vascular structures. Fatal situations that progress to disseminated intravascular coagulation (DIC) may occur.

It causes damage to important structures with low resistance in the extremities due to the effect of heat on the musculoskeletal system as it passes through the tissues. This event may cause compartment syndrome in the extremities. Compartment syndrome is a condition that requires early diagnosis and urgent fasciotomy. If no intervention is made, amputations are inevitable. (Kerimov R & friends, 2010)

Diagnosis And Treatment

In low-voltage injuries, if the patient has no complaints on admission, his/her ECG and routine tests are normal, and there are no entrance/exit traces, discharge can be planned without the need for additional follow-up.

In high-voltage injuries, the patient's cardiac monitoring should be performed, fluid resuscitation should be started, and urine color and myoglobin level should be monitored by applying a bladder catheter in case of renal involvement or rhabdomyolysis. If the urine color is dark, fluid resuscitation should be started without waiting for the myoglobin level, with a urine output of 100 ml / h in adults and 1-1.5 ml / kg / h in children weighing less than 30 kg. (ATLS, 2018)

Fluid resuscitation in burns is important in preventing fluid loss in the body, supporting circulation and protecting organ functions. It is important to maintain electrolyte balance here. It starts according to the burn surface area, degree and Parkland formula. Fluid calculated according to 4 ml/kg x burned body percentage should be given in 24 hours. In the presence of myoglobinuria, mannitol and bicarbonate infusion is administered. However, in such advanced cases, a burn unit opinion should be sought.

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CHAPTER V

Practical Approaches in the Management of Patients with Invasive Mechanical Ventilation in the Emergency Department

Murtaza KAYA[1]

The increasing number of critically ill patients in the emergency department, coupled with prolonged lengths of stay, has led emergency physicians to assume the care of patients requiring mechanical ventilation for longer periods (1). The critical illnesses necessitating advanced airway management and their corresponding laboratory values are summarized in Tables 1 and 2.

Understanding mechanical ventilation becomes challenging for many clinicians due to the use of similar terms for the same mode or settings among various ventilator brands or complex terminology arising from different codifications. A clearer comprehension of

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fundamental terms and recognition of the mechanical ventilators at our disposal will facilitate their use. Despite the growing availability of different mode options with various combinations on mechanical ventilators, knowledge of basic operating principles will ease the utilization for emergency physicians amidst advancing technology.

Ventilation Fundamentals: (2)

Control (target) variables are goals determined based on the selected mechanical ventilation mode. For example, there are pressure-controlled and volume-controlled ventilation modes.

Conditional variables are dependent variables in mechanical ventilation. For instance, in volume-controlled ventilation modes, tidal volume is a specified parameter, while pressure is a conditional variable and can vary with each breath.

Trigger: It is the factor initiating inspiration. Trigger can be pressure-triggered, flow-triggered, or time-triggered.

Cycle: It is the process of determining the end of inspiration and the beginning of exhalation. For example, a mechanical ventilator can cycle based on volume, pressure, or time.

Peak Inspiratory Pressure (PIP or Ppeak): It is the maximum pressure in the airways at the end of the inspiratory phase. This value is typically displayed on the ventilator screen. As this value is generated during airflow, PIP is determined by the resistance and compliance of the airway. Since all pressures in mechanical ventilation are reported in "cmH2O," targeting a PIP value <35 cmH2O is advisable.

Plateau Pressure (Pplat) is the pressure remaining in the alveoli during the plateau phase, where airflow stops or breath-holding occurs. To calculate this value, clinicians can press the "Inspiratory Hold" button on the ventilator. Plateau pressure effectively reflects the pressure in the alveoli with each mechanical breath and indicates compliance in the airways. To prevent lung injuries, Pplat should be maintained below 30 cmH2O.

Positive End-Expiratory Pressure (PEEP) is the positive pressure remaining at the end of expiration. This additional applied positive pressure helps prevent alveolar collapse at the end of expiration, assisting in preventing atelectasis. PEEP is typically set as part of the initial ventilator settings at 5 cmH_2O or more. Clinically set PEEP is also known as extrinsic PEEP or ePEEP and is used to distinguish it from pressure that can arise from air trapping. Traditionally, unless otherwise specified, the term "PEEP" refers to ePEEP.

Intrinsic PEEP (iPEEP) or auto-PEEP is the pressure remaining in the lungs due to incomplete exhalation and can occur in patients with obstructive lung disease. This value can be measured using the "expiratory hold" button on the mechanical ventilator.

Driving Pressure (ΔP) is a term that defines pressure changes occurring during inspiration and is equal to the difference between plateau pressure and PEEP (Pplat - PEEP). A ΔP of <15 cmH_2O has a positive impact on mortality.

Inspiration Time (iTime) is the duration allocated to deliver the determined tidal volume (in volume control settings) or the set pressure (in pressure control settings).

Expiration Time (eTime) is the duration allocated to fully exhale the delivered mechanical breath.

Inspiratory/Expiratory Ratio (I:E) is usually expressed as 1:2, 1:3, etc. The I:E ratio can be adjusted directly or indirectly on the ventilator by changing the inspiration time, inspiratory flow rate, or respiratory rate. Traditionally, reducing the ratio implies increasing the expiration time.

Peak Inspiratory Flow is a value expressed in L/min that represents the rate at which the breath is delivered. A common flow rate is 60 L/min. Increasing or decreasing inspiratory flow is a way to indirectly affect the I:E ratio. For example, if the inspiratory flow is increased, the breath is delivered more quickly, leaving more time for expiration.

Tidal Volume (TV or VT) is the gas volume delivered to the patient with each breath. Tidal volume is expressed both in milliliters (e.g., 450 mL) and in milliliters per kilogram of ideal body weight (e.g., 6 mL/kg).

Respiratory Rate (RR or f) is the number of mandatory breaths delivered to the patient by the ventilator per minute. It's essential to report both the set RR and the patient's actual RR, as the patient may breathe above the set rate. Both values can be found on the ventilator screen.

Minute Ventilation (VĖ, Vė, or MV) represents the ventilation the patient receives in 1 minute and is calculated by multiplying tidal volume and respiratory rate (TV x RR), expressed in liters per minute (L/min). The basic minute ventilation for most healthy adults is between 4-6 L/min, but critically ill patients attempting to compensate for metabolic acidosis may require a minute ventilation of 12-15 L/min or higher to meet their demands.

Basic Ventilator Modes

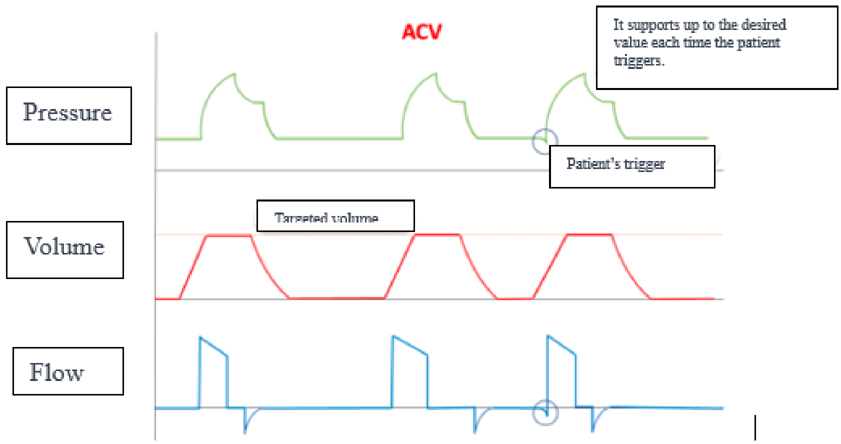
Typically, volume and pressure-controlled modes are used at the initiation of mechanical ventilation, often following intubation. In volume-controlled ventilation, a predetermined volume is delivered to the patient with each breath, based on the desired respiratory rate. In pressure-controlled mode, airflow is provided to the patient up to the desired upper pressure limit. As the set peak pressure in pressure-controlled ventilation may not generate the desired tidal volume, adjustments to the duration of each cycle can be made to alter tidal volume (3).

In invasive mechanical ventilation, ventilation modes are shaped by how inspiration begins, continues, and expiration concludes within the respiratory cycle.

Assist-Controlled (AC) Mode:

Assist-controlled is a frequently used ventilation mode and one of the safest modes employed in emergency services. In this mode, patients receive the same breath with the same parameters set by the clinician for each breath (2). While patients may take additional breaths or receive extra breaths, each breath will convey the same set parameters. Assist-controlled mode can be volume-targeted (volume control, AC/VC), where the clinician sets a desired volume, or pressure-targeted (pressure control, AC/PC), where the clinician selects a desired pressure. (Figure 1)

Figure 1: Assist Control Ventilation



Synchronized Intermittent Mandatory Ventilation (SIMV)

Synchronized Intermittent Mandatory Ventilation (SIMV) is a type of ventilation that falls under the category of Intermittent Mandatory Ventilation (IMV). The set parameters are similar to Assist-Controlled (AC), and settings can be volume-controlled (SIMV-VC) or pressure-controlled (SIMV-PC). Like AC, each mandatory breath in SIMV will convey the same set parameters. However, with additional spontaneous breaths, the patient only receives support up to the set pressure (2).

For instance, in SIMV-VC, a tidal volume (TV) can be set, and each delivered mechanical breath obtains this tidal volume as long as the patient does not take spontaneous breaths. However, spontaneous breaths in this ventilation mode will have more variable tidal volumes, based on patient and airway factors. (Figure 2)

Pressure Support (PS, PSV):

Pressure Support (PS, PSV) is a partial support ventilation mode where the patient receives a constant pressure (PEEP) and an additional "supportive" pressure when triggering the ventilator breath.

In this mode, clinicians can adjust both PEEP and the desired pressure added on top of PEEP. However, all dependent variables, such as peak inspiratory flow, respiratory rate, and tidal volume, are determined based on the patient's effort (2).

The patient triggers each breath, and when the patient ceases effort, the ventilator stops delivering the driving pressure or the desired pressure on top of PEEP. Therefore, patients placed on this ventilation mode need to have the ability to take spontaneous breaths.(Figure 3)

Figure 2: Synchronized Intermittent Mandatory Ventilation (SIMV)

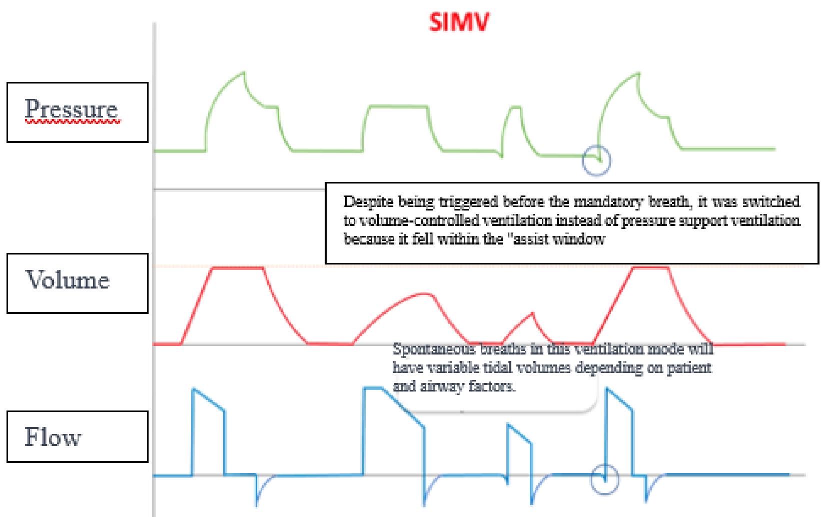
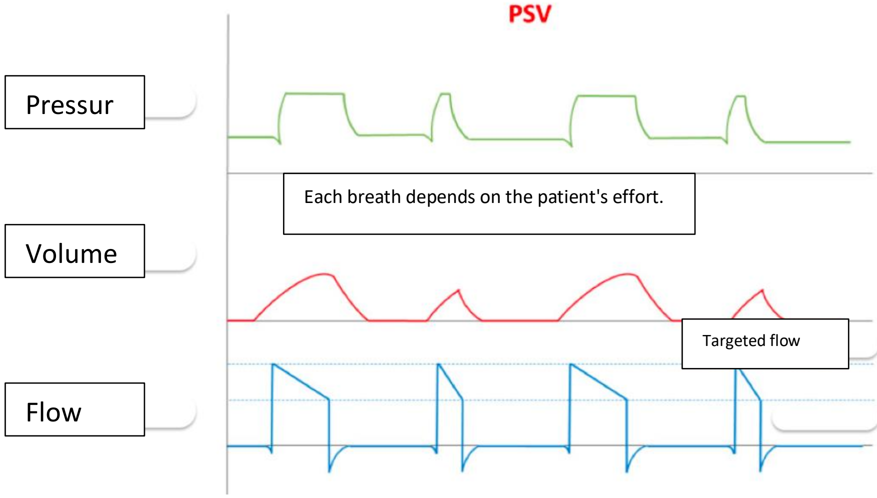


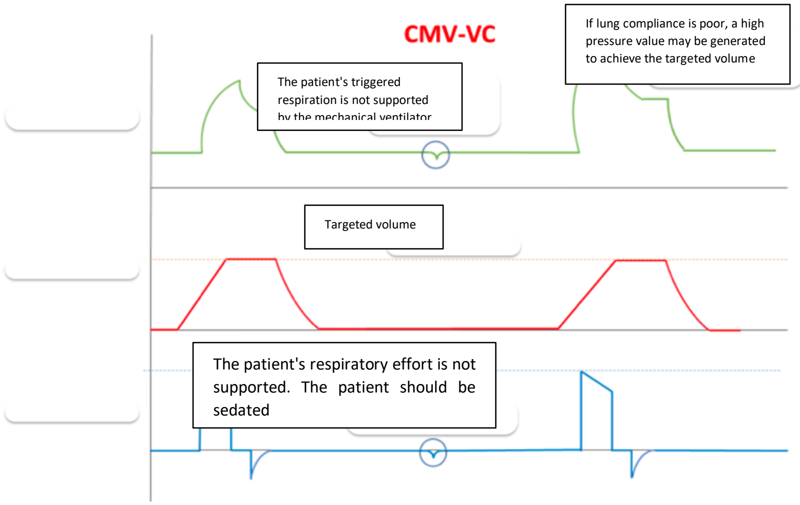
Figure 3: Pressure Support Ventilation (PSV)



Continuous Mandatory Ventilation (CMV):

Continuous Mandatory Ventilation (CMV) provides breaths only for a predetermined duration. During CMV, minute ventilation is entirely determined by the set respiratory rate and tidal volume. The patient does not initiate additional minute ventilation beyond the set minute ventilation on the ventilator. This may be due to pharmacological paralysis, profound sedation, coma, or the absence of stimulation to increase minute ventilation beyond the set physiological need. CMV does not require the patient to perform any work (2). (Figure 4)

Figure 4: Continuous Mandatory Ventilation (CMV)



<u>Clinical Cases in Mechanical Ventilation</u>

Asthma: While early invasive mechanical ventilation is generally not desired for asthma patients, it may be necessary in cases where the clinical condition deteriorates rapidly. Entubated patients should continue to receive aggressive bronchodilator, steroid, and magnesium treatments. After the initial intubation in this patient group, moderate to deep sedation and neuromuscular blockade may be required. Due to the risk of barotrauma, great attention should be paid to prevent the development of Auto-PEEP. To extend the expiratory time, the respiratory rate should be reduced, the I/E ratio decreased, inspiration time shortened, and inspiratory flow increased. Since excessive tidal volume would prolong the expiratory time, it is more appropriate to administer a lower tidal volume (6-8 ml/kg) (5).

Chronic Obstructive Pulmonary Disease (COPD): Patients with (COPD) have amphysematous lungs due to chronic bronchitis causing mucus plugs and obstruction leading to collapse of small airways during expiration. Similar to asthma, time should be given to expiration in this group. Therefore, a low respiratory rate, low tidal volume, and low I/E ratio should be set. Since the risk of developing Auto-PEEP is higher, more time should be allowed for expiration, and initially, a higher PEEP value should be set to prevent collapse, unlike in asthma patients. In this patient group with chronic hypoxemia, the saturation level should be maintained between 88-92% (6).

Traumatic Brain Injury (TBI): Patients with (TBI) are at risk of increased intracranial pressure (ICP). Hyperventilation of patients leads to vasoconstriction due to the decrease in $PaCO_2$, resulting in increased ischemia, while hypoventilation leads to increased intracranial pressure due to vasodilation resulting from the rise in PaCO2. For the provision of brain parenchymal perfusion, the minute ventilation should be targeted at 7-8 L/min, maintaining the normal range of $PaCO_2$ between 35-40. Since trauma patients are hypermetabolic, slightly higher minute ventilations may be appropriate. It is essential to avoid hyperoxia, and PaO_2 pressures should not exceed the range of 85-100 to prevent reperfusion injury and the production of free radicals (7).

Ischemic Stroke: In ischemic stroke patients, caution should be taken due to the vasoconstriction induced by hypocapnia, which may increase ischemia in the penumbra area. Increased ICP risk is less than in TBI patients, and $PaCO_2$ should be maintained between 35-45. Low tidal volume ventilation (6-8 ml/kg) can be initiated. Since they are less hypermetabolic compared to TBI patients, minute ventilations can be set at 5-6 L/min. Avoiding hyperoxia is crucial, and saturation levels should be kept above 94% (8).

Intracranial Hemorrhage: Management of patients with intracranial hemorrhage is similar to ischemic stroke and TBI patients. Due to the risk of increased intracranial pressure, $PaCO_2$ should be maintained between 35-40. Avoiding hyperoxia, low tidal volume ventilation (6-8 ml/kg) should be provided. In this patient group, where rapid changes in blood pressure values affect mortality, preparedness to intervene immediately in response to ventilation-related changes in blood pressure is crucial (9).

Status Epilepticus: For patients in status epilepticus, short-acting paralytic agents should be preferred to facilitate repeated examinations. Due to hypermetabolism and lactic acidosis, minute ventilations should be set at 8-10 L/min. Other saturation, PaO_2, and $PaCO_2$ values should be kept within normal ranges.

In conclusion, for critically ill patients requiring advanced airway management, emergency physicians must be well-versed in invasive mechanical ventilation. Mechanically ventilated critical patients should have close monitoring, and invasive ventilation should be provided with careful attention to arterial blood gas values.

Table 1. Some Clinical Conditions Requiring Invasive Mechanical Ventilation

Respiratory arrest or inability to maintain airway
Shortness of breath, tachypnea, acute respiratory acidosis, and exacerbation of Chronic Obstructive Pulmonary Disease (COPD) with at least one of the following: • Cardiovascular hemodynamic instability • Alteration of consciousness • Inability to maintain airway • Clinical deterioration despite non-invasive treatment
Deepening hypoxia despite the application of a high-flow oxygenation system with a high FiO2
Decreased vital capacity
Acute severe asthma attack
Acute hypoxemic respiratory failure in an immunocompromised patient
Traumatic brain injury
Acute respiratory failure in neuromuscular diseases

Table 2. Decision for Invasive Mechanical Ventilation with Numerical Values

Parameters	**Values**
Respiratory Rate	>35 breaths/dk
Tidal Volume	<5 mL/kg
Vital Capacity	<10 mL/kg
Negative Inspiratory Force	< -25 cm H_2O (2.44 kPa)
Minute Ventilation	<10 L/min
Increase in $PaCO_2$	>10 mmHg (1.33 kPa)
Alveolar-Arterial Gradient (FiO_2=1) >450 (FiO_2=1)	>450
PaO_2 /PAO_2	<0.15
PaO_2 under O_2 Support	<55 mmHg (7.32 kPa)

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CHAPTER VI

Emergency Department Triage Software Systems

Harun YILDIRIM

The Definition and Purpose of Triage

The overcrowding of Emergency Departments (ED) has become an increasingly universal public issue. The growing demand for medical care and the insufficient bed capacities in hospitals and emergency services contribute to the escalating nature of this problem. This situation leads to a decline in the quality of care, high mortality rates among both admitted and discharged patients from the emergency department, and an increase in the proportion of patients leaving the emergency department without being seen (1,2). The first point where the emergency condition of patients is assessed occurs during the triage stage in ED. Therefore, most emergency services have a triage system in place to facilitate the prioritization of patients. Derived from the French word "Trier," meaning "to select, classify, separate," the purpose of triage is to categorize emergency department patients based on the severity of their condition, ensure timely intervention, prevent preventable adverse events and clinical deterioration, contribute to the reduction of mortality and morbidity, limit overcrowding, and facilitate the efficient use of limited emergency service resources (3). Triage application is performed by healthcare professionals who have received training in this regard. The concept of triage was first used on the battlefield in the 18th century. The aim during that time was to distinguish soldiers who were likely to die from those less injured. Thus, priority was given to those who were less injured and could quickly recover and return to the battlefield (4). In emergency departments, the implementation of triage started in the early 1960s in the United States (5).

The Systems Used Worldwide

Since the early 1990s, various official triage scales have been developed in many countries to standardize the implementation of triage (6). An ideal triage system should be valid, reliable, and practical. It should allow for an objective assessment across all segments of society and age groups. It should enable the quick categorization of patients in need of emergency care and prompt diagnosis. The sensitivity of the triage application should reflect the seriousness of the illness or injury and should not be affected by the capacity of the emergency department (7). Different triage systems developed by countries come in 2-level, 3-level, 4-level, and 5-level categories (Table 1). The most widely used triage systems globally are the 3-level and 5-level triage systems (Table 2,3). The American College of Emergency Physicians (ACEP) has been endorsing the 5-level triage model since 2003.

Table 1:Triage Systems

2 Levels	3 Levels	4 Levels	5 Levels
Emergent Non-emergent	Emergent Urgent Non-urgent	Life-threatining Emergent Urgent Non-urgent	Resuscitation Emergent Urgent Non-urgent Referred

Table 2: Three-level triage system

1-Emergent	The patient should be treated as soon as possible without delay. The patient's illness or injury may lead to disability or death.
2-Urgent	The patient must undergo diagnosis and treatment in the emergency department. They should be periodically monitored until diagnosis and treatment are completed.
3-Non-urgent	The patient may wait for a long time until seeing a doctor or may be directed to primary health care services.

In the 1960s, the healthcare reform in the United States led to an increase in the number of patients seeking emergency care. As a result, emergency departments (EDs) quickly implemented triage systems to ensure that patients who needed urgent attention were prioritized for treatment, allowing others to safely wait in the waiting area. These systems consisted of three categories. In Australia, the increase in the number of patients arriving at emergency services by ambulance in the 1970s resulted in the development of several local 5-level triage systems. These triage systems formed the basis for the Australian Triage Scale (ATS) implemented in 1993 (8). In 1998, a study was conducted in the United States to investigate the validity and reliability of the 3-level triage system (10). The results of this study were weak, leading to the development of a new 5-level triage system called the Emergency Severity Index (ESI). During the same period, due to the increasing number of emergency department visits, Canada and the United Kingdom recognized the need for a more systematic approach. Consequently, the Canadian Triage and Acuity Scale (CTAS) and the Manchester Triage System (MTS) were developed and implemented in sequence (11,12). In the Netherlands, a gradual decrease in visits to general practitioners and an increase in direct emergency department admissions, coupled with a growing elderly population, led to an increased demand for emergency services. Consequently, in the Netherlands, 5-level triage systems such as MTS and ESI have been implemented since the 21st century (13). In our country, the triage scale mandated by the Ministry of Health is applied in all state hospitals and many university hospitals. This system is a 3-level triage system based on color coding and can also be applied as a 5-level triage system with its subcategories. The triage system uses red, yellow, and green colors.

Table 3: Five-Level Triage

1-Resuscitation	Those requiring immediate, simultaneous assessment, and treatment	Unconsciousness Absence or cessation of breathing Pulse absent/unable to be obtained
2-Emergent	Those who need to be assessed and treated within 10 minutes	Severe respiratory distress Intense chest pain Severe bleeding Life and limb-threatening major trauma Severe head trauma Psychotic patients Obstetric emergencies Anaphylaxis Convulsions Major burns Malignant arrhythmias
3-Urgent	Those who need to be assessed within 30 minutes.	Deep cuts Head trauma without loss of consciousness Chest pain Abdominal pain Severe headache Fever of 39°C or higher in adults Allergic reactions Open fractures Spinal trauma

		Dialysis patients Transplant patients
4-Non-urgent	Those who require assessment and treatment within 60 minutes	Common cold Sinusitis Sore throat Vomiting Diarrhea Lower back pain Skin rash Earache Sprains Superficial abscesses Insect bites Minor burns Foreign object in the ear/nose Vaginal discharge
5-Referred	Those requiring assessment and initiation of treatment within 2 hours.	Follow-up examination Diagnostic tests Injection, transfusion, infusion Vaccination Dressing Suture removal

5-Level Triage Systems Used Worldwide

Australia Triage Scale

In 1994, the National Triage Scale (NTS) was introduced in Australia, and later in 2000, it was further developed and named ATS. ATS is a 5-level complaint-based triage system that takes into account the time to initiate medical intervention along with medical approaches (14).

Canadian Triage and Acuity Scale

CTAS, a 5-level triage system developed in Canada, was introduced in 1999, inspired by the NTS, and is widely used across the country. Each level has specific evaluation times by a physician, which are different from ATS. Additionally, a triage scale has been developed for pediatric patients (15).

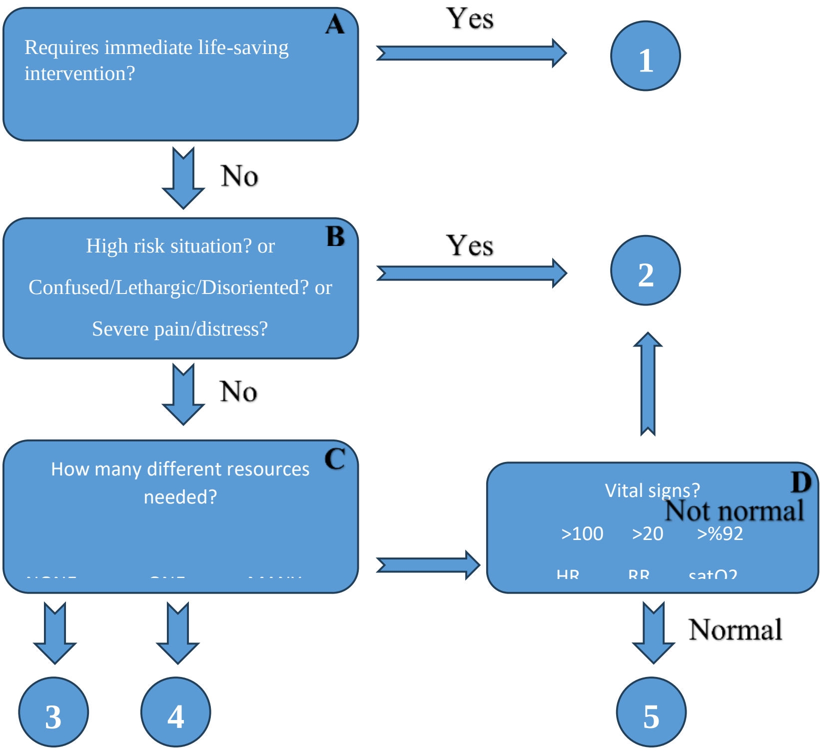
Manchester Triage System

MTS, a 5-level triage system developed in the United Kingdom in 1994, is widely used in the European Union. Similar to CTAS and ATS, this complaint-based system determines priority and risk prediction for patients in need of emergency care. MTS has 52 flowcharts used to assess patient complaints, and each of these diagrams identifies key discriminators such as "vital danger, pain, consciousness status, blood loss, fever, and acute onset." The triage personnel must choose one of these 52 diagrams. In classification, 5 colors are used: red for emergent, orange for very urgent, yellow for urgent, green for standard, and blue for non-urgent situations (16).

Emergency Severity Index

ESI is a triage application developed in the late 1990s in the United States. Unlike complaint-based systems, ESI is a triage system that classifies patients based on the estimated resource needs and utilization, as shown in Figure 1. It is still successfully used in the United States and some European countries. The expected time for patient evaluation by a physician is not defined in this system. In ESI, the triage application consists of 4 decision points where the triage nurse asks specific questions. The first point assigns ESI level 1 or 2 if there is a life-threatening condition. For example, hemodynamically or respiratorily unstable patients are designated as triage level 1. Conditions with the potential to be life-threatening, such as chest pains suggesting acute coronary syndrome, altered consciousness, intoxications, and psychiatric illnesses, are assigned level 2. Conditions ranging from triage level 3 to 5 are classified based on resource needs and vital signs. In this context, resource utilization situations such as the need for X-rays or intravenous treatment take precedence over the physical examination in the decision-making stage. The group with triage level 1 consists of patients with the highest resource needs, while the group with triage level 5 consists of patients who do not require any tests or treatment (17).

Figure 1: Emergency Severity Index



HR: Heart rate, RR: Respiratuar rate

Despite the widespread adoption of these triage systems worldwide, there are some disadvantages to human-performed triage. Decision-making based on the clinical condition during triage level determination leads to high variability among practitioners, preventing an objective assessment. Sometimes, a symptom indicating a critical condition may go unnoticed for a critically ill patient. This situation can lead to prolonged waiting for medical observation for the critical patient and, consequently, an increase in the risk of mortality and morbidity (18). In addition, a patient who does not need medical care may exaggerate symptoms or complaints, misleading the triage practitioner. This situation can prevent the timely identification of a critical patient or lead to the unnecessary use of emergency service resources. These scenarios have prompted the need for computer-based triage software systems to standardize the triage process and provide an objective assessment for each patient.

Digital Transformation in Triage Applications

The increase in the number of visits to emergency departments today leads to longer waiting times for patients in the emergency room. Prolonged waiting times result in:

-Increasing resuscitation procedures before admission to intensive care,

-Increased risk of mortality and morbidity,

-Extension of hospital stay,

-Unnecessary use of emergency service resources,

- Physical and psychological fatigue of healthcare personnel,

-Increased spending on health,

-It causes decrease in patient satisfaction (19,20).

Due to these reasons, algorithms based on logistic regression analysis have been developed for triage software systems. Some of these systems have achieved successful results in predicting emergency department lengths of stay, forecasting cardiac arrest, and predicting mortality. Decision-making support systems (DMSS), or simply decision support systems (DSS), are systems developed to assist practitioners and provide support throughout all stages of the decision-making process. In the 1980s, with the development of Artificial Intelligence (AI), AI tools were integrated into DSS, giving rise to intelligent decision support systems (i-DSS). A specific technology used in i-DSS research is machine learning, which enables DSS to acquire new information and adapt to the user or changing environment. An i-DSS extends traditional DSS by harnessing the power of modern computers to support and enhance decision-making. For example, an i-DSS can respond quickly and successfully to new data and information without human intervention, handle confusing and complex situations, learn from previous experiences, apply information to understand the environment, recognize the relative importance of different events, and provide advice or act on behalf of humans (with the decision-maker's predefined authorization). In a clinical setting, DSS is referred to as clinical decision support systems (CDSS). It provides information and recommendations to clinicians, staff, and patients. CDSS is commonly used to meet clinical needs such as ensuring accurate diagnoses, timely screening for preventable diseases, preventing medication side effects, or managing pain. Thus, CDSS has the potential to increase efficiency, reduce costs, and alleviate patient discomfort. The goal of such systems is not to replace decision-makers (clinicians, patients, and healthcare organizations) but to provide relevant information and support in decision-making processes (21).

Bonavita et al. (22) developed a triage tool in the form of a 10-question survey using Google Forms during the COVID-19 pandemic with the aim of preventing unnecessary visits of Multiple Sclerosis (MS) patients to the MS center and the spread of infection. They aimed to evaluate patients in three steps: pre-hospital (before patients with appointments interacted with the healthcare facility), during triage (via chatbot and telehealth), and post-interaction (for follow-up). With this system, they planned to prevent both unnecessary visits to MS centers and the spread of infection among MS patients. Additionally, it would eliminate inequality for MS patients who are far from the MS center.

Vântu et al. (23) from Transylvania University of Brașov in Romania aimed to assign an emergency code to each patient after triage through a study focused on the "Machine Learning" approach. This would enable early diagnosis for patients and facilitate medical record procedures. They considered 560,468 admissions from three adult emergency departments. Demographic data, past medical histories, vital signs, and complaints of patients were recorded. They developed a system based on Logistic Regression, Random Forest Tree, and NN-Sequentail algorithms using the ESI as a reference. They classified patients as critical 30% (ESI level 1,2), urgent 43% (ESI level 3), and non-urgent 27% (ESI level 4,5). As a result, the system using the NN-Sequentil algorithm provided the most accurate results and was found to perform better in predicting the non-urgent patient group. The system developed using the Logistic Regression algorithm yielded the worst results. The system developed using the Random Forest Tree algorithm was found to be good at predicting the urgent patient group but had low sensitivity and specificity.

Chip-Jin Ng et al. (24) considered the 4-level classical Taiwan Triage System (TTS) insufficient for predicting patients' resource utilization and hospital admission. They developed the 5-level Taiwan Triage and Acuity Scale (TTAS) based on the Canadian Triage and Acuity Scale (CTAS) and the Electronic Clinical Decision Support Tool for TTAS (eTTAS) with simultaneous computer software systems. Thirty-three head nurses were trained as instructors, and 142 nurses were trained as practitioners for the implementation of TTS and eTTAS. An 11-member national working group defined the criteria and identified the main complaints for TTAS and eTTAS. Emergency department admissions between 10:00 AM and 10:00 PM were collected from 33 centers over approximately 10 months. Patients under 17 years old were excluded from the study. Demographic data, resource utilization, length of stay in the emergency department, and patient outcomes were recorded for analysis. ESI was used for resource utilization. The on-duty triage nurse used the classical TTS, and simultaneously, 33 head nurses and 142 practicing nurses used eTTAS blindly. An observer also conducted observations for suitability assessment. Overall, there was an 87% agreement between the instructor and research nurses using eTTAS. As a result, significant differences were observed in the length of stay, resource utilization, and hospital admission prediction compared to TTAS. TTAS found that Level 1 patients used the most resources, and Level 2 patients had the longest stay in the hospital.

In China, the 4-level China Emergency Triage Scale (CETS) is currently applied by nurses, where the level is determined based on vital signs. Huilin Jiang et al. (25) developed an e-Triage system using four different Machine Learning Models. They compared CETS and e-Triage on patients presenting with suspected cardiovascular diseases (17,661 cases). The results indicated successful triage classification in all four models (Table 4).

Table 4: Prediction ability of 4 machine learning models in patients with suspected cardiovascular disease in the test data

Model	Accuracy	AUC	Macro F1
Multinominal Losistic Regression	0,743	0,908	0,430
Random Forest	0,745	0,919	0,513
eXtreme Gradient Boosting	0,785	0,937	0,478
Gradient-boosted decision tree	0,767	0,921	0,419

In the United States, Yoshihiko R. et al. (26) conducted a study comparing triage systems developed using four different Machine Learning Models based on the Emergency Severity Index (ESI) with a reference triage model created using the Logistic Regression algorithm. The study included approximately 135,470 emergency department visits over about 8 years. Triage criteria included age, gender, vital signs, complaints, and comorbid conditions. The results showed that the reference model performed well in predicting patients with triage levels 1 and 2 (49.6%), but it was not effective in predicting patients with levels 3-5. Triage systems developed with Machine Learning Models were found to better predict patients with triage levels 3-5 (71-81%). Additionally, these Machine Learning Models showed better performance in predicting hospital admissions (Table 5).

Table 5: Performance of the reference and machine learning models in the test set

Outcome and model	**AUC**	**P Value**	**NRI (+)**	**P Value (+)**
Critical care outcome				
Reference model	0.74 (0.72–0.75)	Reference	Reference	Reference
Lasso regression	0.84 (0.83–0.85)	< 0.001	0.39 (0.32–0.46)	< 0.001
Random forest	0.85 (0.84–0.87)	< 0.001	0.07 (0.003–0.14)	0,04
Gradient boosted decision tree	0.85 (0.83–0.86)	< 0.001	0.32 (0.25–0.38)	< 0.001
Deep neural network	0.86 (0.85–0.87)	< 0.001	0.73 (0.67–0.79)	< 0.001
Hospitalization outcome				
Reference model	0.69 (0.68–0.69)	Reference	Reference	Reference
Lasso regression	0.81 (0.80–0.81)	< 0.001	0.53 (0.50–0.55)	< 0.001
Random forest	0.81 (0.81–0.82)	< 0.001	0.66 (0.63–0.68)	< 0.001
Gradient boosted decision tree	0.82 (0.82–0.83)	< 0.001	0.63 (0.61–0.66)	< 0.001
Deep neural network	0.82 (0.82–0.83)	< 0.001	0.68 (0.65–0.70	< 0.001

AUC: area under the curve, NRI: net reclassification improvement

**P value was calculated to compare the area under the receiver-operating-characteristics curve (AUC) of the reference model with that of each machine learning model*

Symptom Checkers

People today are increasingly using the internet to research health problems. The United Kingdom's national online health portal, NHS Choices, reports over 10 million monthly visits. In the United States, more than a third of adults attempt to self-diagnose using the internet. An example is the i-Triage application, a symptom checker, which reports over 50 million annual uses (27-29). Self-diagnosis on the internet is commonly conducted through search engines. Due to the potential for search engines to direct users to complex and unverified information, there has been a recent increase in symptom checker programs to aid patients in self-diagnosis and direct them to appropriate care settings. These programs use computer algorithms to ask users a series of questions about their symptoms and prompt them to provide detailed information. These programs serve two functions: first, to facilitate self-diagnosis based on symptoms, and second, to provide appropriate triage information to guide the patient. The diagnostic function presents a series of diagnoses based on the symptoms and provides information related to those diagnoses. The triage function informs the patient whether they need any medical care and, if so, which healthcare facility they should seek (30-32). Symptom checkers can encourage seeking emergency healthcare in life-threatening situations or reassure individuals that medical care is not necessary in non-emergent cases, allowing them to stay at home. In conditions like viral upper respiratory infections, these programs can reduce unnecessary visits to healthcare facilities and prevent the misuse of antibiotics. However, there are several concerns associated with these programs. If they fail to provide accurate guidance for seeking emergency healthcare in life-threatening situations, it may lead to worsened conditions, increased mortality, and morbidity. Alternatively, if individuals who do not require medical care are advised to seek it, it may result in an increase in unnecessary visits to healthcare facilities, excessive resource utilization, and increased costs.

Hannah L. Semigran and colleagues (33) evaluated 23 symptom checkers in their study. They used 45 patient scenarios (15 emergent, 15 non-emergent, 15 not requiring a medical visit) for the assessment. The study focused on the accuracy of diagnoses and triage recommendations provided by the symptom checkers. Overall, a 57% rate of appropriate triage recommendations was observed. The most accurate triage recommendations were found to be provided for the emergent patient group. Diagnostic accuracy rates were found to be low, with the highest diagnostic accuracy rate (40%) observed in the group of patients not requiring a medical visit.

The integration of computer-based software systems and emerging Artificial Intelligence (AI) into triage applications brings numerous advantages but also entails disadvantages. Algorithms in software systems may be misinterpreted by humans, leading to ethical issues. In the event of an erroneous triage application or misdiagnosis, it is unclear who would be responsible. Additionally, biases can worsen in cases of insufficient data concerning factors such as genetics and race that may impact medical care. Another issue is the privacy and security concerns arising with technological advancements. Data and information stored about patients could be unlawfully disseminated. Finally, traditional healthcare personnel applying triage systems use their emotional and intuitive aspects in decision-making. Software systems and artificial intelligence lack these characteristics, making it challenging to display a humane approach to patients (34).

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CHAPTER VII

Advanced Life Support

Abdil ÇOŞKUN[1]

Introduction

Early diagnosis and interventions for a patient with unstable vital functions undoubtedly contribute to the mortality and morbidity of the patient. For patients with impaired or absent respiratory and/or circulatory functions (arrested patients), basic life support (BLS) is performed in pre-hospital conditions to restore these functions, and advanced life support (ALS) is performed in healthcare centers. BLS practices do not include equipment (excluding Automated External Defibrillator - AED), advanced airway techniques, vascular access, and drug administration, while ALS encompasses all of these. These procedures are commonly referred to as cardiopulmonary resuscitation (CPR).

CPR was officially endorsed by the American Heart Association (AHA) in 1963, and in the same year, standardized CPR

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guidelines were published for non-healthcare providers for the first time (1). AHA and the International Liaison Committee on Resuscitation (ILCOR) periodically release Advanced Cardiovascular Life Support (ACLS) guidelines for adults.

General management

Still emphasized in the guidelines, excellent CPR – effective chest compressions and early defibrillation form the foundation of BLS and ALS (2,3). Some studies have shown incorrect and intermittent chest compressions in certain cases (4,5). Effective chest compressions in adults involve compressing the chest by 5-6 cm, at a rate of 100-120 compressions per minute, allowing the chest to recoil between compressions.

In the treatment of Ventricular Fibrillation (VF) and Pulseless Ventricular Tachycardia, a biphasic defibrillation shock should be administered, and CPR should not be interrupted until the defibrillator is charged. After delivering the shock, chest compressions should be resumed immediately; in other words, pulse should not be checked after the shock, and CPR should be continued (6).

In resuscitation procedures, it is essential to avoid excessive ventilation of patients. Excessive ventilation increases intrathoracic pressure, reduces preload-venous return, and leads to decreased cardiac output, resulting in impaired coronary and cerebral perfusion. Therefore, in intubated patients, continuous chest compressions and 8-10 ventilations per minute are recommended, deviating from the traditional basic life support guidelines of 30 chest compressions to 2 breaths (7).

First management and EKG

The sequence in resuscitation procedures, formerly known as ABC (Airway-Breathing-Circulation), was revised to CAB in the 2010 ACLS guidelines and beyond. This change prioritizes excellent chest compressions, airway management, and ventilation support.

The importance of early defibrillation is also emphasized. In non-cardiac arrest cases, it is recommended to administer oxygen (aiming for a saturation of 94% or above), establish intravenous access, and closely monitor with EKG. If the EKG shows ST-segment elevation myocardial infarction (STEMI), the patient should be evaluated for thrombolytic therapy or coronary angiography (8).

Airway Management

During chest compressions, for ventilation, a Bag-Valve-Mask (BVM) or supraglottic airway devices (such as LMA, Combitube) should be chosen. Endotracheal intubation can be performed without interrupting chest compressions or should be done once circulation has been restored (9). In some randomized trials comparing patients who received BVM or supraglottic airway devices with those who underwent endotracheal intubation in pre-hospital cardiac arrest, primary outcomes, specifically neurological recovery results, were found to be similar (10,11,12). In patients supported with Bag-Valve-Mask without intubation, synchronized ventilation should be delivered in a 30/2 ratio, while in intubated patients, asynchronous ventilation at a rate of 6-8 breaths per minute is recommended. Excessive ventilation volume/frequency can increase intrathoracic pressure, decrease venous return, reduce cardiac output, and further compromise cerebral perfusion. Another consequence of hyperventilation is an increased risk of gastric distention, leading to regurgitation and aspiration (13).

During CPR, when administering 100% oxygen, in patients who have achieved spontaneous return of circulation (ROSC), oxygenation should be maintained at a saturation of 94%, and patients should be protected from hyperoxia (33). Cricoid pressure should not be applied during intubation (13).

When using a Bag-Valve-Mask (BVM), the use of oro-nasopharyngeal airway can improve ventilation quality. For the confirmation of endotracheal tube placement and assessment of CPR quality, a waveform capnography detector can be used. If a waveform is not present, a waveform-less carbon dioxide detector can be used (13).

Drugs

During CPR, drug administrations are preferably done through a peripheral venous route; however, if that is not accessible, the intraosseous route (IO) is also considered safe (14). The drug doses are the same as for the IV route. In the absence of IV or IO access, drug administration through the endotracheal tube can be done at 2-2.5 times the standard dose. Drugs that can be administered through the endotracheal route include adrenaline, naloxone, lidocaine, vasopressin, and atropine (13).

Adrenaline: It is the only drug commonly used independently of the rhythm in cardiac arrest patients. It is a sympathomimetic catecholamine that binds to alpha1-2 and beta 1-2 receptors. It increases coronary perfusion pressure. According to ACLS guidelines, adrenaline is recommended at intervals of every 3-5 minutes, with a dose of 1 mg intravenously (IV) or intraosseously (IO).

Atropine: It has no place in the treatment of cardiac arrest. In patients with symptomatic bradycardia, it can be initiated at 1 mg every 3-5 minutes, with a maximum dose of 3 mg.

Amiodarone and Lidocaine: Evidence suggests that they provide little benefit in terms of survival in refractory pulseless ventricular tachycardia and ventricular fibrillation (2,15). In the ACLS guidelines, Amiodarone and Lidocaine can be used in patients with the expectation of a third shock after the second defibrillation. The dose for Amiodarone is typically 300 mg IV/IO bolus followed by a repeat dose of 150 mg IV/IO bolus. For Lidocaine, the usual dose is 1-1.5 mg/kg IV/IO bolus, with a repeat dose of 0.5-0.75 mg/kg IV/IO bolus.

Magnesium: It is not part of the routine CPR protocol, but it is administered in cases of polymorphic VT (Torsade de pointes) at a dose of 2-4 grams IV/IO magnesium sulfate.

Vasopressin: The use of vasopressin during CPR does not show superiority over patients receiving adrenaline alone; therefore, the ACLS guidelines do not recommend the use of vasopressin (16).

Calcium: Despite its vasopressor and inotropic effects, calcium has been found to be of no benefit during CPR (17,18). In some cases during CPR (such as hyperkalemia, calcium channel blocker toxicity), calcium may be used.

Sodium Bicarbonate: According to meta-analyses of randomized and observational studies involving more than 20,000 patients, routine use of sodium bicarbonate during CPR has been found to be of no benefit (19,20). In certain situations during CPR (such as advanced metabolic acidosis, hyperkalemia), sodium bicarbonate at a dose of 50-100 mEq IV may be used.

Management of specific arrhythmıas

The patient is quickly assessed for consciousness, breathing, and pulse. For patients with effective breathing and a pulse, treatment plans are tailored based on their clinical stability (stable or unstable) and rhythm status (tachycardia, bradycardia). There are four main rhythms that can be observed during cardiac arrest. These are:

Shockable: Pulseless Ventricular Tachycardia (PVT), Ventricular Fibrillation (VF)

Non-shockable: Asystole and Pulseless Electrical Activity (PEA)

PVT and Ventricular VF effective resuscitation for patients in this rhythm involves continuous chest compressions and early defibrillation until the defibrillator is reached. Chest compressions should be uninterrupted until the defibrillator is accessed. When the defibrillator arrives, attach it to the patient, and continue chest compressions until it is charged. Assess the rhythm, and if a shockable rhythm is present, deliver the appropriate shock to the patient. After the shock, resume chest compressions. Assess the patient's pulse and rhythm every 2 minutes (Figure 1) (21). During this process, investigate the possible causes that could lead to the patient's arrest (Table 1) (22). Administer adrenaline after the first shock - 2 minutes of CPR - and the second shock should be given immediately. Adrenaline should be administered every 3-5 minutes at a dose of 1 mg IV/IO. In cases of refractory Pulseless Ventricular Tachycardia (NVT) and Ventricular Fibrillation (VF), treatment with amiodarone or lidocaine can be considered (Figure 1).

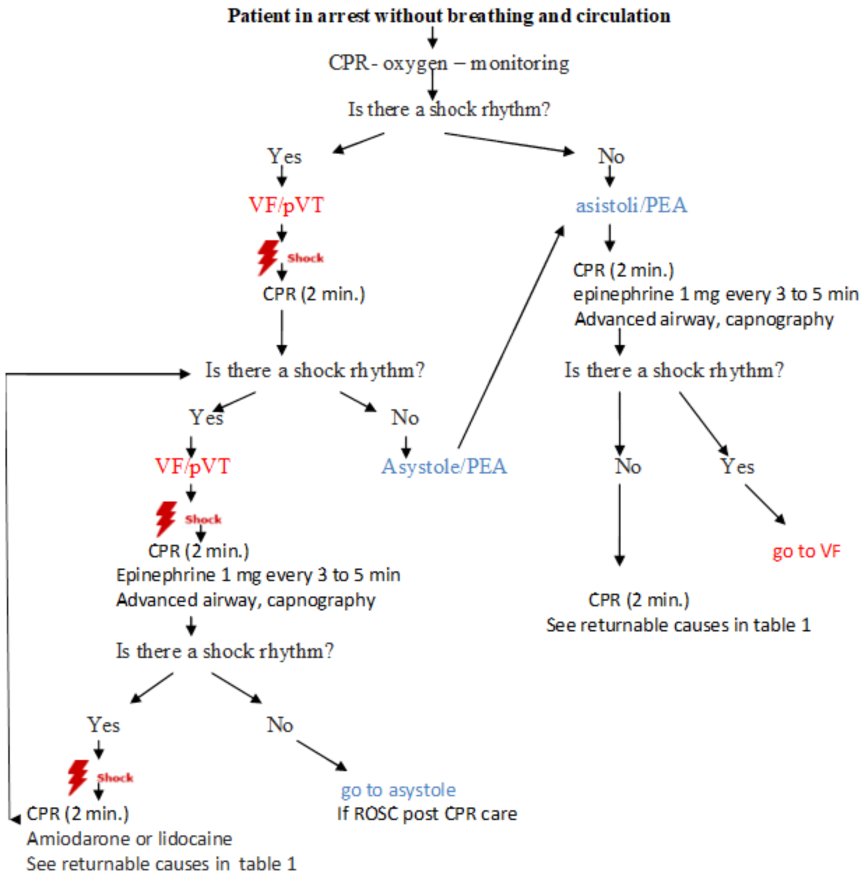

Figure 1. Advanced Life Support Algorithm

CPR: Cardıo Pulmonary Resuscitation PEA: Pulseles Electrical Activity

ROSC: Return of Spontaneous Circulation

Defibrillation

Early defibrillation increases the likelihood of transitioning to a perfusing rhythm and improves the patient's chances of survival. Bifasic defibrillators are recommended due to their increased effectiveness even at lower energy levels (23). ACLS guidelines recommend that the initial dose of defibrillation should be at the manufacturer-recommended level, typically ranging from 120 to 200 Joules. In the case of a monophasic defibrillator, a fixed dose of 360 J is commonly recommended. In cases of refractory recurrent Ventricular Fibrillation (VF), a transition from the classic defibrillator pad placement in the anterior-lateral position to the anterior-posterior position can be considered. This change may contribute to terminating VF and increasing the likelihood of spontaneous return of circulation (24). The defibrillator pad placements are illustrated in figure 2 (25).

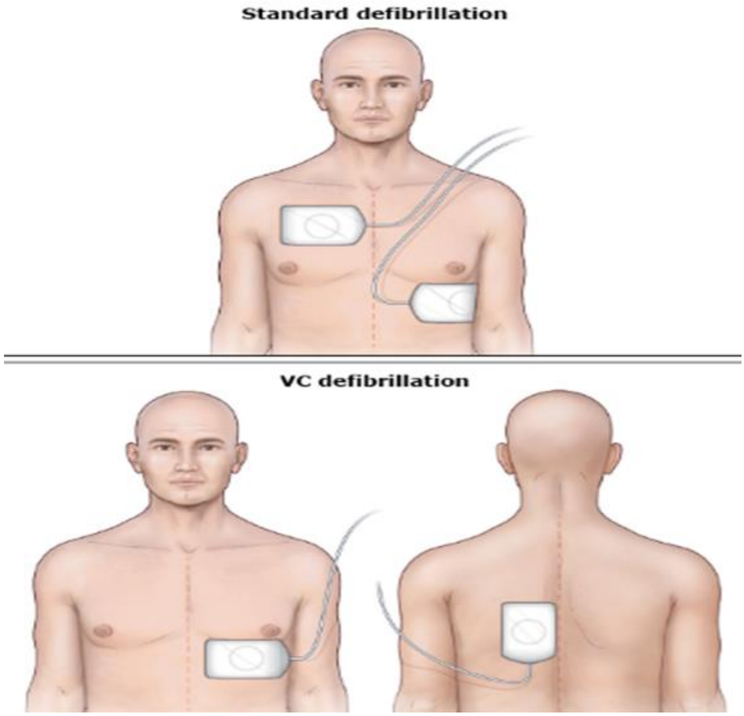

Figure 2. Defibrillator pad placements

VC: Vector Change – Anterior Posterior placement

Venoarterial Extracorporeal Membrane Oxygenation (VA ECMO)

ECMO is an advanced life support method that can be used when standard treatment is not effective in cases of severe respiratory and cardiac failure. With increasing technical advancements and a growing body of successful data, its utilization is on the rise (26). One of the applications is Venoarterial ECMO used during cardiac arrest, known as Extracorporeal Cardiopulmonary Resuscitation (ECPR).

Evidence indicates that in selected cardiac arrest patients (those under 60 years of age, with shockable rhythms, witnessed CPR, etc.), Extracorporeal Cardiopulmonary Resuscitation (ECPR) performed in addition to traditional CPR has a positive impact on mortality by achieving perfusion in target organs (27). However, while the optimal patient selection and implementation strategies remain unclear, the ACLS guidelines state that ECPR can be considered for treatment in appropriate patients (16).

Asystole and PEA

Asystole is a rhythm where there is no mechanical or electrical cardiac activity. Pulseless Electrical Activity (PEA), on the other hand, appears as if there is a rhythm on the monitor, but there is no mechanical contraction of the heart that can generate a pulse and blood pressure. The management of these rhythms is based on excellent CPR, investigating and reversing potential causes of arrest (28). Defibrillation is not used for these rhythms. Adrenaline is administered as soon as possible, along with chest compressions (3). Review Algorithm 1 and Table 1 for further guidance.

Table 1. Reversible causes of Arrest

Case	**Associated clinic**
Hypoxia	Upper respiratory tract obstruction, neuromuscular disease, lung disease (COPD, pulmonary edema)
Hypovolemia	Severe burns, diarrhea, bleeding, sepsis, trauma, malignancy
Hypokalemia	Gastrointestinal loss, alcohol, diuretics, diabetes – watch out for hypomagnesemia
Hyperkalemia	Excessive potassium intake, renal damage, rhabdomyolsis, tumor lysis syndrome, hemolysis
Hypothermia	Environmental exposure, burns, drowning, drug overdose, senile
Thrombosis	Pulmonary thrombo embolism, Acute coronary syndrome
Toxins – Poisoning	Alcohol, drugs, suicide
Tension pneumothorax	Central catheter, mechanical ventilation, lung disease (such as asthma), trauma
Cardiac tamponade	Trauma, malignancy, infection
Acidosis	İmpairment of renal function, sepsis, shock, diarrhea
Anemia	Gastrointestinal bleeding, malnutrition

Monitoring

Monitoring is crucial for measuring the quality of CPR during cardiac arrest and assessing the patient's return to circulation through clinical and physiological observations. ACLS recommends continuous monitoring (29). End-tidal CO2 measurement reflects cardiac output and CPR quality. Effective chest compressions increase cardiac output and perfusion. Increases in end-tidal CO2 measurements (greater than 10 mmHg) may be indicative of spontaneous return of circulation (30).

Arterial catheterization involves the insertion of a catheter into an artery for various medical purposes, such as continuous blood pressure monitoring, blood sampling, or obtaining arterial blood gases. It is a procedure that may be performed during cardiopulmonary resuscitation (CPR) and after the return of spontaneous circulation (ROSC). Importantly, chest compressions should not be interrupted during the performance of these procedures (13).

During CPR, ultrasound procedures can be beneficial in determining the etiology, assessing CPR effectiveness, and determining cardiac apex activity (31).

Ultrasonography (USG) and echocardiography

Bedside ultrasound (USG) usage should not impede CPR procedures. The ACLS 2020 guidelines recommend bedside ultrasound and echocardiographic assessment to identify reversible causes of arrest (such as cardiac tamponade, tension pneumothorax, pulmonary embolism) and evaluate cardiac apex activity (32).

Specıal groups of arrest patıents

Traumatic arrest

In cases of traumatic arrest, the ATLS (Advanced Trauma Life Support) guidelines recommend an approach following the ABCDE method (33).

A. Airway preservation - Cervical spine stabilization

B. Respiratory preservation - Adequate oxygenation

C. Circulation control - Hemorrhage control

D. Neurological assessment

E. Removal of the patient's clothing - Attention to hypothermia

Airway obstruction (tongue, aspiration, foreign body, edema, hematoma) is a significant cause of mortality following trauma (34)

In trauma patients with established airway patency, appropriate oxygenation and ventilation should be ensured. Particularly in chest trauma, pathologies such as tension pneumothorax, cardiac tamponade, and massive hemothorax that can lead to arrest should be considered. Diagnosis and treatment plans should be developed (35).

In trauma patients with hemodynamic instability despite appropriate fluid therapy (IV 20ml/kg saline), blood transfusion may be necessary. Blood transfusion is typically composed of packed red blood cells, plasma, and platelets in a 1:1:1 ratio (36).

In traumatic arrest patients receiving anticoagulant therapy, reversal of anticoagulation should be considered in the presence of life-threatening bleeding (37). For unstable patient groups, bedside Traumatic Ultrasound (FAST) assessment is crucial for monitoring circulation and detecting significant pathologies (such as cardiac tamponade, intra-abdominal bleeding) (38,39).

In trauma patients, beyond general bleeding control measures, resuscitative endovascular balloon occlusion of the aorta (REBOA) may be considered in traumatic arrest cases where bleeding is the cause (40,41).

Sepsis arrest

In patients with septic shock leading to cardiac arrest, the traditional CPR protocol is applied. The initial-hour general approaches for a patient with septic shock are as follows:

• Review symptoms, signs, and laboratory data for the source of infection.

• In addition to other blood results, lactate and procalcitonin values are important.

• Regulate appropriate fluid therapy (crystalloid fluids) for the patient.

• If there is no hemodynamic response to appropriate fluid, consider norepinephrine as a vasopressor.

• Consider source-directed antibiotic therapy within the first hour.

• Maintain a target hemoglobin level above 7 in anemic patients.

• In cases of adrenal insufficiency and refractory shock, consider steroid therapy (hydrocortisone 100 mg IV).

• Plan appropriate sedation and analgesia for the patient (42,43).

Acute coronary syndrome arrest

Acute coronary syndrome is a common cause of cardiac arrest (44). In patients who present with chest pain before the arrest and subsequently experience arrest, an EKG should be taken if spontaneous return of circulation is achieved. In the group with cardiac pathology, ST-segment elevation on the EKG and regional wall abnormalities on echocardiography are frequently observed (45). For elderly hypertensive patients with out-of-hospital arrest, elevated initial troponin levels, and shockable rhythms, early consideration should be given to invasive coronary intervention (46).

Pulmonary thromboembolism (pte) arrest

Pulmonary Thromboembolism (PTE) is a disease with variable clinical manifestations that can have a widespread and fatal course. The treatment varies based on the patient's clinical presentation, and thrombolytic therapy is used in unstable patients. One such agent is tissue plasminogen activator (tPA), with alteplase being an example (47,48). The FDA-approved dose for IV tPA is 100 mg over 2 hours. In unstable emergency cases of PTE, tPA can be administered as a bolus, as a 15-minute infusion, or as a 50 mg bolus followed by the remaining 50 mg infused over 2 hours. For PTE-related cardiac arrest, a recommended approach is a 50 mg bolus infusion (49).

Patient with arrest related to covıd-19

Approach to suspected or diagnosed arrest in COVID patients has been updated by AHA 2021. Accordingly, wear the necessary personal protective equipment, keep the number of personnel in the team to a minimum, use a negative pressure room if possible, keep the room door closed, use mechanical CPR devices, and use HEPA filters (50,51).

Drowning-related cardiac arrest

In these cases, traditional CPR is initiated. However, since hypoxemia is prominent in these patients, CPR should start with rescue breaths (52). If an accessible defibrillator is available, the shock situation should be evaluated. In this case, the patient and the rescuer should be dry (53).

In cases of hypothermic patients with cardiac arrest due to drowning, CPR efforts are recommended until the body temperature reaches 32 to 35 °C and there is at least a 20-minute asystole rhythm (51). In these cases, ECMO may be attempted for cardiac arrests undergoing traditional CPR (54).

Arrest due to poisoning

In cases of arrest due to poisoning, interventions such as antidote administration and VA-ECMO are considered beyond standard CPR management. Recently, the AHA has updated its guidelines for the focused management of poisoned critical or arrest patients (55). According to this update:

- Naloxone (opioid receptor antagonist) administration in cases of opioid overdose can reverse respiratory arrest and prevent arrest.
- In cases of beta-blocker and calcium channel blocker poisoning, if the unstable patient is resistant to vasopressor therapy, high-dose insulin therapy is recommended.
- Patients diagnosed with methemoglobinemia do not typically undergo cardiac arrest management; however, methylene blue is used in these cases. In patients who do not respond to treatment with methylene blue, blood exchange and hyperbaric oxygen therapy can be considered.
- If cyanide poisoning is suspected, hydroxocobalamin or sodium nitrite + thiosulfate can be administered
- In the case of digoxin poisoning, digoxin-specific antibodies can be used
- In the case of unstable local anesthetic toxicity (such as bupivacaine), IV lipid emulsion can be used.
- In cases of agitation with sympathomimetic ingestion, sedation should be administered for patient management.
- In benzodiazepine toxicity, flumazenil can be used to reverse central and respiratory symptoms. However, flumazenil carries potential risks. For example, it may increase the risk of seizures in benzodiazepine-dependent individuals and can lead to cardiac rhythm disturbances in hypoxic patients.
- In cases of cardiac arrest related to cocaine use, lidocaine can be used as it counteracts the effects of

cocaine. Additionally, sodium bicarbonate can be used in cases of wide complex tachycardia and arrest related to cocaine.

- In cases of organophosphate and carbamate poisoning, atropine treatment (1-2 mg IV, doubling every 5 minutes) should be administered in the presence of bronchorrhea, severe bradycardia, bronchospasm, and seizure.
- Early application of VA-ECMO may be life-saving in cases of cardiogenic shock and arrhythmias resistant to conventional treatment.

The recommendation class and level of evidence from the American Heart Association guidelines have not been shared in this section. Additionally, poisoning and toxic syndromes have not been elaborated on as they are the subject of another chapter.

Post CPR care

When to stop CPR

In patients with cardiac arrest, there is very limited evidence regarding the process of discontinuing CPR, making the decision challenging (90). However, the following factors can be guiding in making this decision (56,57,58).

- Duration of no-flow rhythm exceeding 30 minutes
- Time interval between collapse and initiation of CPR
- Patient's age, comorbidities, and prior functional capacity (functional dependency)
- Objective data, such as a low $EtCO_2$ level after 20 minutes of CPR (below 10 mmHg; during this time, tube placement should be confirmed, and CPR quality should be reassessed).

- In cases of drowning, prolonged CPR (several hours) can lead to recovery (59).

The care of patients who achieve return of spontaneous circulation (ROSC) after CPR is complex and critical. Ischemic damage can occur in many organs. In summary, the following considerations should be taken into account:Evaluate the need for early invasive coronary intervention (46).

- Target oxygen hemoglobin saturation levels between 94% and 100% (60).
- Noradrenaline and dobutamine are the preferred choices in shock therapy (61).
- Aim for targeted therapeutic hypothermia, maintaining temperatures at no more than 36 degrees Celsius (62).
- Monitor patients for seizures, and initiate benzodiazepines or anticonvulsant agents in the event of a seizure (63).
- Close monitoring of glucose and other metabolic values, especially renal protective measures, is crucial for achieving good neurological survival (64).

Early recognition of cardiac arrest, prompt intervention, appropriate management of life-threatening rhythms, and comprehensive patient evaluation will contribute positively to the patient's mortality and morbidity.

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1 Last Call for Emergency Medicine

The world population is increasing day by day. The increasing and aging population brings with it an increase in the demand for health services. Not only in developing countries but also in developed countries, the most frequent deaths occur due to causes requiring emergency intervention. In other words, it is possible to prevent at least some of these deaths with effective emergency interventions. For this reason, emergency medicine has an increasingly important role in the field of health care. This book aims to intervene effectively in preventable emergencies and to improve the knowledge and skills of healthcare professionals to manage critical situations.

Hyperkalaemia is a life-threatening emergency that can occur in the course of many diseases. Our book provides the reader with the latest information on recognizing this serious clinical condition, and managing it with current guidelines, treatment protocols, and care strategies.Trauma patients are one of the most common and preventable causes of death in emergency medicine practice. Pregnant patients present special challenges that further complicate the situation. Both maternal and fetal health need to be protected and this situation needs to be handled specially. Our book provides up-to-date information on trauma management in pregnant patients, recognizing possible secondary conditions and increasing the ability to provide effective emergency intervention.

The practice of cardiopulmonary resuscitation is improving every year. Cardiopulmonary resuscitation, which is an important part of emergency medicine practice, has a wide perspective from basic skills that every healthcare professional should know to interventions that require special equipment and training. Current information about Double Sequential External Defibrillation, which has been frequently discussed in recent years, is conveyed to the reader in this book. Electrical injuries are one of the important clinical situations that emergency medicine professionals have to deal with. It should be kept in mind that pathologies related to all organs and systems through which current passes can be observed. Information to guide the approach to electrical injuries is included in this book. This book provides reliable and up-to-date information to health professionals by addressing the issues related to the science of Emergency Medicine. It will be a resource that will strengthen the knowledge and skills of readers on the aforementioned topics.

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