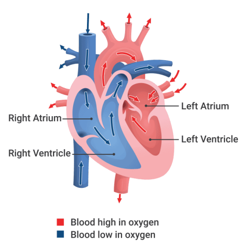
Arrhythmia & cardiac arrest (SCA) د. شذى كاظم عطره/ م. رابعة ت. تخدير / 2024

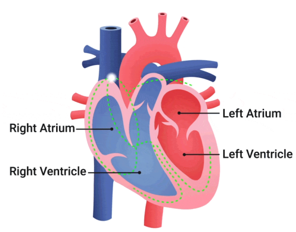
What is an Arrhythmia?

Cardiac arrhythmia broadly **refers** to an abnormal heart rate or rhythm.
In the case of an arrhythmia, the **heart may be beating** too fast, too slow, or in an irregular pattern.
These **abnormal rhythms** are **caused** by disturbances in the electrical signals that **control the heart**.
Arrhythmias can **occur** in healthy hearts and, **most** of the time, they are both short-lived and harmless.
However, **serious arrhythmias** that are prolonged and significantly disrupt heart function are **very dangerous**.
In fact, **certain types of arrhythmia** can **lead to Sudden Cardiac Arrest** (**SCA**) and **death** within a few minutes after onset.
In **these life-threatening** cases, the **heart** becomes **unable** to effectively **pump blood** throughout the body and to the vital organs.
When the **heart no longer** delivers sufficient oxygen to the brain, **syncope** ('fainting") and **death** can occur in **quick** successionتوال .

Arrhythmia Mechanism: Heart Function:

In order to understand how and why arrhythmias occur, it is important to briefly review the structure and function of the heart.
The heart is divided into four asymmetric chambers – the right atrium, the right ventricle, the left atrium, and the left ventricle.
These chambers contract in a carefully **coordinated sequence** so that the heart **pumps** blood throughout the body every time it **beats**.
On the **right side of the heart** (which appears on the left in the diagram), blood enters the right atrium from the body.
This **blood** is then **pumped** to the **lungs** by the **right ventricle** where it becomes **oxygenated**.
Oxygen-rich blood then **returns** to the heart through the **left atrium** before it is **pumped** to the **rest of the body** by the **left ventricle**.
The **upper chambers of the heart**, the **atria**, act as the **receiving** chambers; they fill with blood and **deliver** that blood to the corresponding **ventricle**.
The **ventricles** are the pumping chambers that then **export** the blood to either the **lungs** (right ventricle) or the **systemic** circulation (left ventricle).





All these **chambers** contract in a carefully choreographed dance that is controlled by electrical signals.
The **sinoatrial (SA)** or "**sinus" node** is the **heart's pacemaker**. This **node generates** the **electrical impulses** that make the heart muscles contract. The **sinus node** produces an electrical impulse approximately **60-100 times per minute at regular intervals**.
This **impulse** then **travels** through the atria before reaching the **atrioventricular (AV) node**. The AV node is the gatekeeper. **Located** between the atria and ventricles, this node slows down the electrical signal so that the **atria** are able to **fully contract**. **From** the AV node, the impulses **travel** into the **ventricles**, causing them to **contract**. On an **electrocardiogram, "ECG,"** the thin wavy lines are a diagram of how these electrical signals are propagating throughout your heart.
This **precisely timed** sequence of muscle contraction and relaxation **pumps** blood from the heart to the lungs and the rest of the body.
A loss of precision in this sequence can **compromise** the efficiency and function of the heart. Broadly speaking, an **arrhythmia** happens when there are **disturbances** in the *heart's pacemaker or *electrical conduction pathways.

Classification of Arrhythmias

Arrhythmias can be **classified** in **two** primary ways: 1. *how* it affects the heart rate and 2.*where* in the heart it originates.
A **healthy heart** will slow down and speed up **depending** on much oxygen the body needs.
The **ideal heart rate** of a resting, healthy **individual** is **between 60 to 100 beats per minute (bpm).**

1. **Tachycardia:** A heart rate that exceeds 100 bpm
2. **Bradycardia:** A heart rate below 60 bpm
3. **Supraventricular arrhythmia:** These arrhythmias are caused by malfunctions in the atria, which are the upper chambers of the heart. Supraventricular arrhythmias are further **categorized** into:
   a. atrial flutter, **b**. atrial fibrillation, and **c**. paroxysmal supraventricular tachycardia.
4. **Ventricular arrhythmia:** These abnormal heart rhythms **originate** in the lower chambers of the heart, the **ventricles**. Pre-ventricular contractions, a less-severe ventricular arrhythmia, are extra, abnormal heartbeats that come from the ventricles rather than the **sinus node**. These beats can cause a **fluttering** feelingترفرف , like your *heart skipped a beat; they are relatively common.
   Two lethal arrhythmias that cause Sudden **Cardiac Arrest** (**SCA**) include *ventricular fibrillation and *ventricular tachycardia.

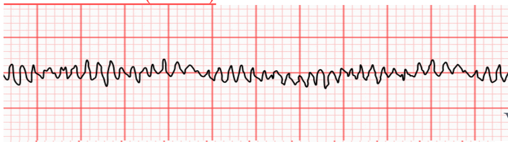
What Arrhythmias can cause Sudden Cardiac Arrest?

Sudden Cardiac Arrest (SCA) is an unexpected loss of heart function **due to** an underlying arrhythmia.
During cardiac arrest, the heart is no longer able to pump oxygen to the brain or body. **Consequently**, victims of SCA become unresponsive and stop breathing normally.
When someone **suffers** SCA, their heart is likely in **either** pulseless ventricular tachycardia **or** ventricular fibrillation. **While** many cardiac arrhythmias are **not immediately** dangerous, both of these **lethal** ventricular rhythms **will lead to death within minutes if** left **untreated**.

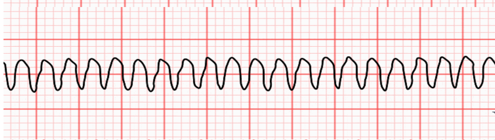
a. **Pulseless ventricular tachycardia** is a life-threatening fast heart rhythm that originates in the lower part of the heart, the "ventricles". During pulseless ventricular tachycardia, the ventricles are contracting very rapidly and are **not able** to effectively pump blood throughout the body.

b. **Ventricular fibrillation** is another ineffectual heart rhythm where the heart beats with erratic, rapid electricalكهربائية سريعة وغير منتظمة impulses. These chaotic electrical signals cause the ventricles to essentially quiver **rather** than pump blood to the rest of the body.

Fortunately, both of these cardiac arrhythmias **can be treated** with a lifesaving **defibrillation shock** from an Automated External Defibrillator (AED).



Ventricular Fibrillation

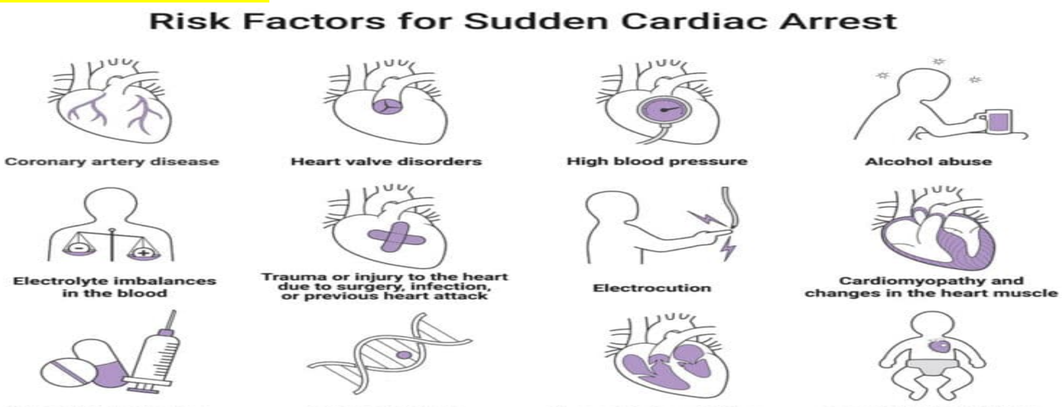


Ventricular Tachycardia

Sinus Rhythm

Sudden Cardiac Arrest Risk Factors and Causes

Arrhythmias are **caused** by a diverse range of conditions and substances that affect the physiology and electrical function of the heart. The lethal arrhythmias that cause Sudden Cardiac Arrests are no different. All the following **conditions can increase risk of SCA**.



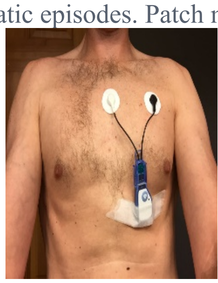
Symptoms and Diagnosis of Arrhythmia

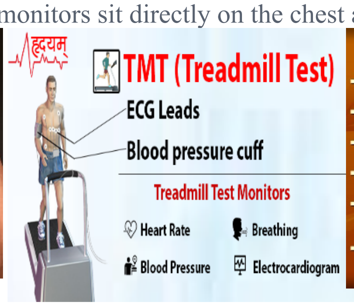
When arrhythmias occur, symptoms may include *dizziness, *shortness of **breath**, *discomfort in the chest, *heart palpitations, and *fatigue.

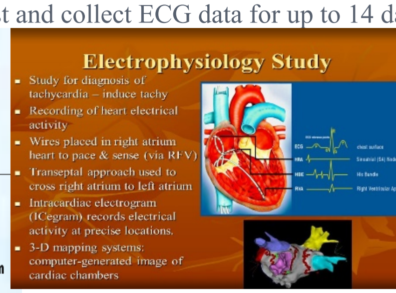
In most cases, arrhythmias are episodicعرضي , appearing without warning, and, in some direوخيمة cases, are only discovered **after** Sudden Cardiac Arrest!

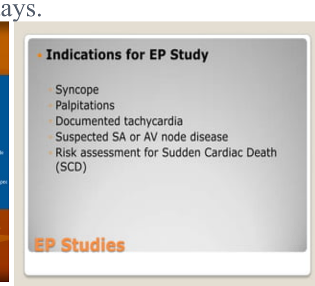
In **diagnosing an arrhythmia**, physicians rely on a variety of tests that record and analyze the heart rhythm. Some of the **more common tests** include:

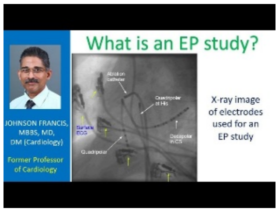
1. Electrocardiogram: The ECG records the heart's electrical activity and depicts يرسم how impulses propagate throughout the heart. It is a simple and common procedure in which electrodes are attached to the bare chest. These electrodes relay electrical signals from the heart to a machine that then displays graphed patterns on a monitor for easy analysis.
2. **Holter/Event/Patch Monitor:** These are small, portable ECG devices that are commonly used to record the heart rhythm for anywhere from 48 hours to 14 days. Holter monitors are useful for patients with transient symptoms or cardiac arrhythmias that may be difficult to detect during a shorter period of time. Event monitors specifically record the heart rhythm when activated during symptomatic episodes. Patch monitors sit directly on the chest and collect ECG data for up to 14 days.

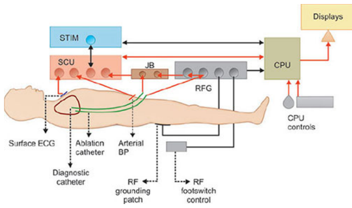


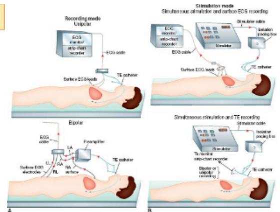


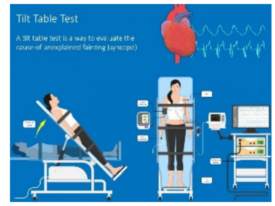












3. **Stress Test:** This test, also known as a treadmill or exercise test, is performed to assess heart function and diagnose potential arrhythmias during physical activity on a treadmill or stationary bike. To better visualize blood flow and heart function, patients might also receive a nuclear stress test where they receive a small and safe amount of radioactive tracer. If a patient cannot exercise on a treadmill or stationary bike, they may also be given pharmacological agents to simulate cardiac stress.
4. **Electrophysiologic Testing (EP Study):** During an EP study, electrode catheters are temporarily threaded through the peripheral veins or arteries and they enter the heart while patients are under local anesthesia. The electrode catheters are then positioned in the **atria**, **ventricles**, or **both** where they record the heart's electrical signals. This recording **provides** a highly-detailed map of the cardiac electrical impulses during each **heartbeat**.
5. **Tilt Table Test:** For patients **who** often **feel** faint or dizzy, a tilt table test can help determine whether those feelings are due to an abnormal heart rate or blood pressure. During this exam, patients lie on a rotating table that raises their head 60 to 80 degrees from a horizontal lying position. This movement and positioning intends to trigger symptoms while patients are being monitored.

Treatment of Arrhythmia

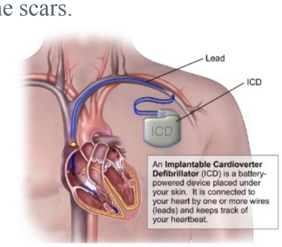
Based on the type and severity of the arrhythmia, treatment can take many different forms. Some treatment options include:

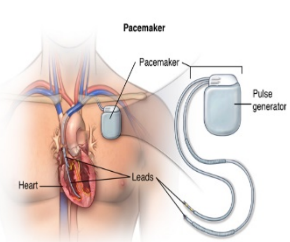
1) **Lifestyle changes:** It is important to have a healthy diet reduce your risk of heart disease at any **age**. Physicians may advise patients to adopt lifestyle changes that mitigate the risk of worsening an arrhythmia. Some suggestions include eating healthy diets, cessation of smoking, and stress management.
2) **Medications:** A host of medicines can be administered **carefully** to treat abnormal rhythms. Of course, caution and proper **diagnosis** should be taken when administering these (or any) **drugs**. **Some common drugs** that can be used to treat arrhythmia are described in the table below.

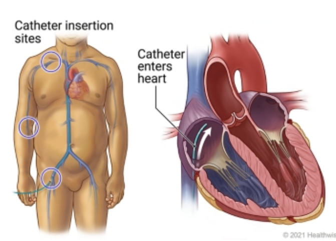
Medication	**How it Works**
Beta blockers	By binding to adrenoreceptors, these drugs reduce heart rate and the strength of heart muscle contraction.
Ion channel blockers	These drugs change the electrolyte balance of calcium, sodium, magnesium, or potassium in the cardiac cells and reset electrical conduction pathways to normal.
Blood thinners	By reducing the propensity of blood to clot, blood thinners lower the risk of blockages that may cause heart attacks and strokes.

3) **Surgery:** If lifestyle changes and medication can't solve the problem, more involved procedures may be required. Common **surgical procedures** and implants **include**:

1. **Cardioversion:** Cardioversion involves the use of synchronized electrical shocks to stabilize an irregular heartbeat, often atrial fibrillation or atrial flutter. Unlike defibrillation used to treat patients during cardiac arrest, cardioversion is administered to patients who still have a pulse.
2. **Implantable cardioverter defibrillator (ICD):** This device is inserted surgically under the skin and continuously monitors the electrical impulses of the heart. If there is an abnormal heart rhythm, a corrective electrical impulse is sent to the heart to stabilize the heartbeat. Patients who go into sudden cardiac arrest often receive an ICD which you can learn more about here.
3. **Pacemakers:** A pacemaker is implanted in the abdomen and chest with electrical connection to the heart that enables it to monitor and stabilize the heart rate by producing electrical impulses to counteract problematic electrical signals. Unlike an ICD, pacemakers cannot "shock" the patient in case of a pulseless tachycardia or fibrillation.
4. **Catheter ablation:** This process deliberately creates scar tissue in the heart to stop arrhythmias. The scars block the heart tissue from triggering or conducting abnormal electrical impulses. During surgery, the catheter enters the heart through a vein or artery in the groin and uses either heat or cold to create the scars.







In fact, surgery and anesthesia are inherently dangerous, and as with any medication or procedure, there is always the chance that something can go wrong. Certain patients are **more likely** to experience problems or complications and possibly even death than others because of their age, medical conditions, or the type of surgery they're having. If you're **planning** to have **surgery**, there are ways to lower your risk, including meeting with your anesthesiologist.

Anaesthetic Considerations in Cardiac Patients Undergoing Non Cardiac Surgery

Administering anaesthesia **to patients** with **preexisting cardiac disease** is an **interesting challenge**تحدي مثير للاهتمام .
Most common **cause** of **peri-operative morbidity** and **mortality** in **cardiac patients** is **ischaemic heart disease (IHD).**
Care of these patients require: a. identification of risk factors, **b.** pre-operative evaluation & optimization, **c.** medical therapy, **d.** monitoring and **e.** the choice of appropriate anaesthetic technique and drugs.

Risk factors Influencing peri-operative cardiac morbidity are:

i. Recent **myocardial infarction, ii**. Congestive **cardiac failure, iii.** Peripheral **vascular disease, iv**. Angina pectoris, **v**. Diabetes mellitus, **vi**. Hypertension, **vii**. Hypercholesterolemia, **viii**. Dysrrhythmias, **ix.** Age, **x**. Renal dysfunction , **xi**. Obesity **xii**. Life style and smoking.

Risk stratification

In **1977**, Goldman and colleagues proposed the **land-mark Cardiac Risk Index**. Although not validated prospectively, **this index** was used extensively **for preoperative cardiac risk assessment** for the next two decades.
Subsequently, **other** cardiac risk indices were proposed and adopted. **In 1996,** a 12-member task force of the American College of Cardiology and the American Heart Association (ACC/AHA) published **guidelines** regarding the perioperative cardiovascular evaluation of patients **undergoing noncardiac surgery**.
In **March 2002**, these **guidelines** were updated based on new data. The overriding theme **remains** that "preoperative intervention is rarely necessary, simply to lower the risk of surgery, **unless** such intervention is indicated irrespective of the perioperative context". No test should be performed **unless** it is likely to influence patient treatment.

What is the cardiac risk index?

The Revised Cardiac Risk Index (RCRI) is a popular classification system to estimate patients' risk of **postoperative cardiac complications based** on preoperative risk factors. ***Renal impairment**, defined as **serum creatinine >2.0 mg/dL (177 µmol/L)**, is a component of the RCRI.

What is the RCI index score?

RCI scores were **calculated** to provide an index of change from baseline to postinjury. RCI scores were **calculated** by an independent professional statistician based on methodology described in detail by Iverson et al.

The Revised Cardiac Risk Index (**RCRI**) was developed for **prediction** of major cardiac complications in *non-emergent, *noncardiac surgery.
Major cardiac complications include: a. myocardial infarction, b. pulmonary edema, c. ventricular fibrillation or primary cardiac arrest, and e. complete heart block.
The RCRI is **composed** of **six variables** of approximately **equal** prognostic importance:

1. High-risk surgery (including intrathoracic surgery),
2. History of ischemic heart disease,
3. History of congestive cardiac failure,
4. History of cerebrovascular disease,
5. Insulin therapy for diabetes, and
6. Preoperative serum creatinine >177 µmol/L.

A RCRI ≥3 is **associated** with a risk of major postoperative cardiac complications for more than **11 %** of patients and may be **considered as a cutoff** to **delineate high-risk patients**.
Derived from the original RCRI, a **thoracic risk score (ThRCRI)** for lung resections was established [11] (Table 2.3).

T**he predictive power of both of these scores** in patients undergoing lung resections is **controversial**.

Table 2.2
Revised Cardiac Risk Index

Risk factor	Points
History of coronary artery disease	1
History of heart failure	1
History of cerebrovascular disease	1
High-risk surgery (suprainguinal vascular, intraperitoneal, intrathoracic)	1
Preoperative insuline therapy	1
Serum creatinine > 177 µmol/L	1
Risk of major cardiac event	
Points	**Risk % (95 % CI)**
0	0.4 (0.05 – 1.5)
1	0.9 (0.3 – 2.1)
2	6.6 (3.9 – 10.3)
≥3	≥ 11 (5.8 – 18.4)

CI: Confidence Interval

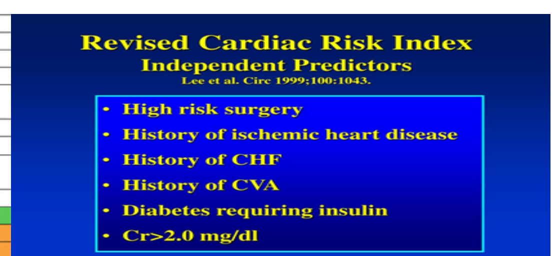


Table 2.3 : **Thoracic Revised Cardiac Risk Index (ThRCRI)**

Risk factor	Points
History of coronary artery disease	1.5
History of cerebrovascular disease	1.5
Pneumonectomy	1.5
Serum creatinine > 177 µmol/L	1
Risk of major cardiac event	
Points	**Risk %**
0	0.9 %
1 – 1.5	4.2 %
2 – 2.5	8 %
> 2.5	18 %

The **Myocardial Infarction** and **Cardiac Arrest** (MICA) risk **calculator** was developed with the intent to **improve predictive power** for major cardiac adverse events as compared to RCRI.

The **model** was **based** on analysis of the National Surgical Quality Improvement Program (NSQIP) database with more than 200,000 patients. **Five predictors** of perioperative risk of MICA at **30 days** were identified: a. type of surgery, b. age, c. functional dependency, d. creatinine >133 umol/L, and ASA class.

What classification is ASA?

The American Society of Anesthesiologists (ASA) physical status classification system is a grading system to determine the health of a person before a surgical procedure that **requires anesthesia**. The purpose of ASA classification is to: Keep a record of your health before

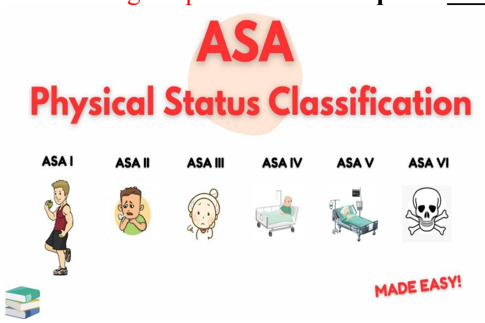


Table. American Society of Anesthesiologists Classification*

ASA Class	Class Definition	Rates of PPCs by Class, %
I	A normally healthy patient	1.2
II	A patient with mild systemic disease	5.4
III	A patient with systemic disease that is not incapacitating	11.4
IV	A patient with an incapacitating systemic disease that is a constant threat to life	10.9
V	A moribund patient who is not expected to survive for 24 hours with or without operation	NA

* Information is from reference 9. ASA = American Society of Anesthesiologists; NA = not applicable; PPC = postoperative pulmonary complication.

The MICA risk calculator resulted in a more accurate cardiac risk prediction than **RCRI**, although no data is available specifically for thoracic surgical patients. The MICA risk calculator is available on the web.

Postoperative pulmonary complications (PPCs) include *respiratory failure, ***re-intubation** within 48 h, *pneumonia, *atelectasis, *bronchospasm, *exacerbation of **chronic obstructive pulmonary disease** (COPD), *pneumothorax, *pleural effusion, and *various forms of upper airway obstruction.

They are a **major** cause of **postoperative morbidity and mortality**, **possibly** accounting for a **higher mortality than cardiovascular complications.**

Pulmonary Risk Scores

The ARISCAT study established a **risk score** for the development of PPCs in a mixed cohort of surgical patients. Seven independent risk factors **emerged**: **low preoperative** *SpO2, *preoperative anemia, *age, *lung infection in the **previous month**, *duration of surgery >2 h, *upper abdominal or intrathoracic surgery, and ***emergent surgery** (Table 2.4).

Oxygen saturation (SpO2) is a measurement of how much oxygen your blood is carrying as a percentage of the maximum it could carry. For a healthy individual, the normal SpO2 should be between 96% to 99%.

Both the patient-related and the procedure-related **risk factors** contributed roughly 50 % to total risk.

Table 2.4: ARISCAT score

Age (years)	*Score*	Preoperative SpO_2, %	*Score*
51 – 80	3	91 – 95	8
> 80	16	≤ 90	24
Respiratory infection in the last month	17	**Preoperative anemia (≤ 10 g/dL.)**	11
Surgical incision		**Duration of surgery, h**	
Upper abdominal	15	> 2 to 3	16
Intrathoracic	24	> 3	23
Emergency procedure	8		

Risk of PPCs (%)	Score
Low (1.6 % [0.6 – 2.6])	< 26
Intermediate (13.3 % [7.6 – 19])	26 – 45
High (42.1 % [29.3 – 54.9])	>45

PPCs Postoperative pulmonary complications, *SpO_2* pulse oxymetry, *OR* odds ratio

2.2.1.4 Lung Function Tests

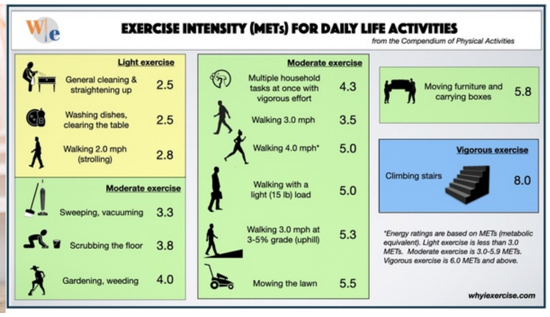
The **degree of dyspnea** is **correlated** with the risk of postoperative **mortality**.

Standardized symptom-limited stair climbing is a simple cost-effective test to objectively determine cardiorespiratory reserve and may have superior predictive ability than traditional Spirometry values. It is a simple, **inexpensive means to predict POCs after high-risk surgery**.

Participants are timed as they climb a 10-step flight of stairs as quickly as possible. Handrail use is allowed if required. The test and timing begin with the examiner saying, “ready, set, go,” and starting the stopwatch once the participant begins moving. Results: Participants ascended and descended stairs at an average speed of 1.3 steps per second; men tended to ambulate stairs more quickly than women.

What causes difficulty climbing stairs?

You may have osteoarthritis or osteoporosis that affects your gait and balance making you unsteady and bent over. Conditions like chronic obstructive pulmonary disease or COPD as it is more commonly known as can cause breathlessness when climbing stairs.



The test involves climbing three flights of stairs without interruption, equivalent to **12 m** ascent that corresponds to metabolic equivalents (METs) greater than 4. The inability to climb more than 12 m warrants further lung functional testing. A patient able to climb at least 22 m (5–6 flights of stairs) has a low risk of postoperative complication, regardless of lung function test results [16].

FEV1 is a reliable predictor of “perioperative complications in thoracic surgery” for patients with FEV1 <70 %. According to the guidelines of European Respiratory Society (ERS) and the European Society of Thoracic Surgery (ESTS) on fitness for lung resection in cancer patients, a predicted postoperative (ppo)-FEV1 <30 % separates patients into **normal** and **high-risk groups**.

It should be remembered that the calculated ppo-FEV1 may overestimate the actual FEV1 on the first postoperative day by about 30 % and that measured FEV1 on postoperative day one may provide more accurate prediction of cardiopulmonary risk [18–20].

On the other hand, patients with a moderate to severe obstructive pulmonary syndrome may have improved respiratory dynamics after lung resection. The ppo-diffusion capacity of the lung for carbon monoxide (DLCO) is another powerful predictor of perioperative complications. According to the ERS/ESTS guidelines, a ppo-DLCO <30 % delineates a high surgical risk.

Peak VO2 allows further **refinement** التحسين of perioperative risk prediction. Patients with values of peak VO2 >20 mL/kg/min qualify for resection up to pneumonectomy, whereas values <10 mL/kg/min indicate a high risk for any type of lung resection [22]. A value of ppo-peak VO2 <10 ml/kg/min is associated with a mortality rate exceeding 50 % [23]. What is the peak VO2? "Exercise capacity can be quantified by measuring the maximum oxygen consumption an individual can use in one minute per kilogram of body weight (ml/kg/min), this number is the VO2peak.

2.2.1.5 Age and Frailty الضعف او الهشاشة

Given age-related decline in **organ function** and **impairment in physiological reserve**, aging is considered a **major** risk factor for perioperative morbidity and mortality.

Sarcopenia ضمور العضلات affects not only limb skeletal muscles but also respiratory muscles and those controlling the upper airways. Accordingly, obstructive sleep apnea and occult aspiration occur more frequently particularly in the context of underlying **neurological disorders** (e.g., previous stroke, dementia, Parkinson disease) [24].

The risk of postoperative hypoxia and **hypercapnia** is **increased** because of altered chemo-sensitivity, respiratory muscle weakness, and increased pulmonary shunting.

Impaired thermogenesis **favors** the occurrence of wound infection, bleeding, and cardiac ischemia events, **resulting** in prolonged postoperative recovery [25].

The **risk** of postoperative cognitive disorder (POCD) is **increased**, especially with **benzodiazepine** premedication [26]. What are Benzodiazepines?

Benzodiazepines are depressants that produce sedation and hypnosis, relieve anxiety and muscle spasms, and reduce seizures. The most common benzodiazepines are the prescription drugs Valium®, Xanax®, Halcion®, Ativan®, and Klonopin®.

Frailty is a compositeمركب **measure** of geriatric conditions. It **includes** measures of *cognitionالإدراك , *strength, *energy, *nutrition, *physical mobility, *mobility, and *mood. Patient assessment for frailty may be a **valuable aid** مساعدة قيمة in determination of **operability and planning of postoperative care**.

A **multidimensional frailty score** was elaborated for prediction of 1-year postoperative **mortality** [27]. It represents an adaptation of the comprehensive geriatric assessment (CGA) and comprises a total of nine items, with a maximal score of 15.

Comprehensive geriatric assessment (CGA) is defined as a multidisciplinary diagnostic and treatment process that identifies medical, psychosocial, and functional capabilities of an older adult in order to develop a coordinated plan to maximize overall health with aging.

The authors used a **cutoff of a score of "5",** to distinguish between a high and a low risk of postoperative **mortality** (mortality >10 %). Although superior to the ASA score for prediction of 1-year mortality, its computation is complicated and time-consuming and must be performed by a medical consultant familiar with the score.

2.2.2 Procedure-Related Risk Factors (Table 2.5)

Table 2.5: Risk classification according to the type of thoracic surgical procedure

Low risk	Intermediate risk	High risk
Pleural drainage	Bullectomy	Pneumonectomy
Pleurodesis	Pleural resection	Extended lung resection
Mediastinoscopy	Lobectomy	Tracheal and bronchial resection
Lung biopsy	Segmentectomy	Mediastinal resections[a]
	Wedge resection	Diaphragmatic resection
		Lung volume reduction surgery
		Lung transplantation

[a]Oesophagectomy, mediastinal tumor resection, thymus resection

2.2.2.1 **Lung Resections**

The literature on the risk of thoracic surgery **primarily focuses** on lung resections, particularly in the context of cancer surgery. Broadly, the **more extensive** the lung resection, the **higher is the risk** of developing postoperative complications.

The **highest risk** of postoperative morbidity and mortality is associated with extended pneumonectomy [28]. The **risk factors** independently associated with **major adverse outcomes** were *age >65 years, *congestive heart failure, *FEV1 <60 %, *underlying benign lung disease, and *extended pneumonectomy. Overall **mortality** was 5.6 % and the incidence of **major morbidity** was 30.4 %.

A study based on data of the French national database for thoracic surgery (EPITHOR) on 4498 patients with lung cancer reports an overall mortality of 7.8 % for pneumonectomy, with risk factors for mortality identified as age >65 years, ASA physiologic status ≥3, underweight, right-sided pneumonectomy, and extended pneumonectomy [29].

A large study based on the STS GTSD, with 18,800 lung cancer resections performed at 111 participating centers revealed an overall perioperative mortality of 2.2 %. Independent predictors of mortality were pneumonectomy, bilobectomy, ASA rating, functional status, renal dysfunction, induction chemoradiation therapy, steroids, age, urgent procedures, male gender, FEV1, and body mass index [30]. According to an analysis based on data of the American National Cancer Database (NCDB) on almost 120,000 patients, 30-day mortality of lung resections for non-small cell lung carcinoma (NSCLC) was 3.4 % overall, with a mortality of 8.5 % for pneumonectomies, 4 % for extended lobectomies and bilobectomies, and 2.6 % for lobectomies and bilobectomies. Mortality for wedge resections was 4.2 % and slightly higher than for lobectomies, which may be explained by a higher rate of tumor recurrences, and a lower functional preoperative status, indicating a more conservative surgical approach.

Overall, a right-sided lung resection carries a higher risk of complications than a left-sided resection owing to greater propensity to bronchopleural fistula formation, a greater increase in right ventricular afterload, and potential alteration in cardiac sympatho-vagal balance [29, 31].

2.2.2.**2 Other Thoracic Surgical Interventions**

Thoracic surgical interventions, which **require** one-lung ventilation (OLV) and a thoracotomy, can be considered **high-risk procedures**. Similar to **lung resections**, they **expose** patients to the risk of **cardiovascular complications** as well as **atelectasis**, **pneumonia**, and **ventilator-induced lung injuries (VILI)** leading **to acute lung injury (ALI)** or **acute respiratory distress syndrome (ARDS)**.

One lung ventilation (OLV) refers to mechanical separation of the lungs to allow ventilation of only one lung. OLV is a standard approach to facilitate surgical exposure for thoracic surgeries, and may be used to isolate a pathologic from a healthy lung to prevent soiling or to allow differential ventilation.

What Is a Thoracotomy? A thoracotomy is a surgical procedure in which a cut is made between the ribs to see and reach the lungs or other organs in the chest or thorax. Typically, a thoracotomy is performed on the right or left side of the chest.

What is Thoracostomy vs thoracotomy?

A thoracostomy is a procedure providers use to insert a chest tube (which drains fluid or air from your chest over a few days). A thoracotomy is a more invasive procedure that allows a surgeon to look into your chest cavity to diagnose or treat illnesses. You might have a chest tube put in after a thoracotomy.

Ventilator-induced lung injuries (VILI) Lung injury can be an adverse consequence of mechanical ventilation. This injury is called ventilator-induced lung injury (VILI) and can result in pulmonary edema, barotrauma, and worsening hypoxemia that can prolong mechanical ventilation, lead to multi-system organ dysfunction, and increase mortality.

What is Ali lung?Acute lung injury (ALI) is a form of acute respiratory failure, defined by hypoxemia and the presence of bilateral infiltrates on chest radiograph, and often referred to by its most severe subset known as acute respiratory distress syndrome (ARDS).

Acute respiratory distress syndrome (ARDS) is a life-threatening lung injury that allows fluid to leak into the lungs. Breathing becomes difficult and oxygen cannot get into the body. Most people who get ARDS are already at the hospital for trauma or illness.

For patients undergoing **esophagectomies**, a **nomogram** has been developed to **predict** the *__occurrence__ and *__severity__ of **postoperative complications,** A nomogram has been developed recently in order to predict the occurrence and severity of postoperative complications after Esophagectomy for cancer. **Independent risk factors** are increasing age, a history of cerebrovascular accident (CVA) or transient ischemic accident (TIA), a history of myocardial infarction, a reduced forced expiratory volume in one second (FEV1), electrocardiographic (ECG) changes, and extensive surgery. The nomogram was validated and proved useful for risk prediction in high-volume hospitals [33].

Lung or pleural biopsies and simple bullectomy with or without pleurodesis under video-assisted thoracic surgery (VATS) are usually short-lasting and minor procedures that require short-term admission in a PACU for monitoring anesthesia emergence, titration of analgesic intravenous regimen, and detection of residual air leakage, lung re-expansion, and atelectasis. Mediastinoscopies can generally be monitored in PACU, with special attention to the risk of occult postoperative hemorrhage.

Uni- or bilateral lung volume reduction surgeries in patients with severe emphysema are considered high-risk procedures given preexisting severe airflow limitations and major impairments in gas exchange. These patients require cautious titration of analgesics (preferably epidural or paravertebral block) and are preferably admitted in ICU or HDU given the risk of life-threatening deterioration in pulmonary function (e.g., bronchopleural fistula, opiate-induced hypercapnic acidosis).

2.2.2.3 Additional Surgical Risk Factors

Little evidence supports the use of a muscle-sparing thoracotomy as opposed to a posterolateral thoracotomy, but incision length may be proportionally related to post-thoracotomy complications [34]. Given limited tissue trauma and consequent reduced neuroendocrine and inflammatory responses, VATS is associated with lower rates of overall perioperative mortality, morbidity (e.g., pneumonia and atrial arrhythmia), as well as length of stay [31]. In the absence of other major risk factors for postoperative complications, patients with a VATS lung resection do not require neuraxial analgesic techniques and are commonly managed in PACU for vital monitoring and anesthesia emergence.

Operative mortality may be lower if board-certified thoracic surgeons perform a minimal case load of procedures [35]. Differences in postoperative mortality rates between hospitals may also be explained by a different quality of postoperative patient management [36]. As a consequence, local experience should be included in the process of postoperative patient triage.

Surgery performed on an emergent basis has repeatedly been associated with worse postoperative outcomes. Various pre- and postoperative scores integrate this factor into risk stratification.

Finally, the occurrence of major intraoperative complications may require a higher level of postoperative monitoring and treatment, than initially planned. Myocardial ischemia, hemodynamically significant arrhythmias, refractory hypotension or hypoxemia, bronchial aspiration, and major bleeding are considered major complications that justify admission in HDU or ICU (Table 2.6).