Updates in evaluation of cardiac patients for non cardiac surgery

Essay

Submitted for partial fulfillment of master degree in anaesthesia

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بسم الله الرحمن الرحيم

(قَالُوا سُبْحَانَكَ لا عِلْمَ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ
الْعَلِيمُ الْحَكِيمُ)

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صدق الله العظيم

Acknowledgment

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Heba Hamdy

Contents

List of Abbreviations

AAA	Abdominal aortic aneurysm
ACC	American colleague of cardiologists
AHA	American heart associations
aPTT	Activated partial thromboplastin time
AR	Aortic regurge
AS	Aortic stenosis
ASA	American society of anaesthesiologists
BB	Beta blockers
BMS	Bare metal stent
bpm	Beat per minute
Bvs	Bioresorbable vascular scaffold
CABG	Coronary artery bypass graft
CAD	Coronary artery disease
CHF	Congestive heart failure
CIED	Cardiac implantable electronic devices
CO	Cardiac output
CXR	Chest x ray
DAPT	Dual antiplatelet
DES	Drug eluting stent
DTS	Dual therapy stent
ECT	Ecarin clotting time
EDV	End diastolic volume
EMI	Electromagnetic interference
ESV	End systolic volume
HCM	Hypertrophic cardiomyopathy
HF	Heart failure

HIT	Heparin induced thrombocytopenia
HR	Heart rate
I.M	Intramuscular
I.V	Intravenous
IABP	Intra aortic balloon pump
IHD	Ischemic heart disease
INR	International normalized ratio
LA	Left atrium
LAD	Left anterior descending artery
LMWH	Low molecular weight heparin
LV	Left ventricle
LVot	Left ventricular outflow tract
METs	Metabolic equivalents
MI	Myocardial infarction
MS	Mitral stenosis
MVO2	Myocardial oxygen consumption
NE	Norepinephrine
NMBA	Neuromuscular blocking agents
NYHA	New york heart association
P	Intraventricular pressure
PCI	Percutaneous coronary intervention
PCWP	Pulmonary capillary wedge pressure
PHD	Pulmonaryheart disease
PT	Prothrombin time
r	Ventricular radius
RCRI	Revised cardiac risk index
RV	Right ventricle

SV	Stroke volume
T	Wall tension
TEE	Trans esophegeal echo
TIA	Transient ischemic attack
TTE	Trans thoracoc echo
UFH	Un fractional heparin
VRA	Vitamin k antagonist

List of Tables

List of Figures

Introduction

Preoperative evaluation is important , because of the fact that we face cardiac patients frequently in operations so we need to perform an evaluation of the patient's current medical status; make recommendations concerning the evaluation, management, and risk of cardiac problems over the entire perioperative period; and provide a clinical risk profile that the patient, primary physician, anesthesiologist, and surgeon can use in making treatment decisions that may influence short and long-term cardiac outcomes. The goal of the consultation is to identify the most appropriate testing and treatment strategies to optimize care of the patient, provide assessment of both short- and long-term cardiac risk, and avoid unnecessary testing in this era of cost containment ***(Eagle et al., 2002).***

The cardiac conditions that assessment should be focused on include: coronary artery disease (CAD) [e.g. Prior myocardial infarction and angina pectoris, heart failure, hypertension, valvular diseases, arrhythmias ***(Rabbitts et al., 2013).***

In addition to identifying the presence of pre-existing manifested heart disease, it is essential to define disease severity, stability, and prior treatment. Other factors that help determine cardiac risk include functional capacity, age, comorbid conditions (e.g., diabetes mellitus, peripheral vascular disease, renal dysfunction, and chronic pulmonary disease), and type of surgery (vascular procedures and prolonged, complicated thoracic, abdominal, and head and neck procedures are considered higher risk) ***(Dirksen et al., 2005).***

In 1977**, Goldman** developed the first cardiac risk index, which included nine variables associated with an increased risk of perioperative cardiac complications. This became known as the Original Cardiac Risk Index (or alternatively the Goldman Index) ***(Goldman et al., 1977).***

In 1999, **Lee** published a cardiac risk index derived from 2893 patients and validated in 1422 patients aged ≥ 50 undergoing major noncardiac surgery, which became known as the Revised Cardiac Risk Index (RCRI). Lee identified six independent variables that predicted an increased risk for cardiac complications. A patient's risk for perioperative cardiac complications increased with number of variables that were present ***(lee et al., 1999).***

In 2007, The Revised Cardiac Risk Index (RCRI) was used widely in clinical practice, research, and was incorporated in a modified form into the 2007 preoperative cardiac risk evaluation guideline from the American Heart Association and American College of Cardiology (ACC/AHA) ***(Fleisher et al., 2007).***

The ACC/AHA guidelines has relied on functional capacity, clinical characteristics of the patient, prescence of active cardiac condition and the extent of the surgical procedure. After preoperative evaluation, the physician should determine the clinical predictors as major, intermediate, or minor ***(Eagle et al., 2002).***

2014 ACC/AHA Perioperative Guidelines stated that two newer tools have been created by the American College of Surgeons, which prospectively collected data on operations performed in more than 525 participating hospitals in the United States. Data on more than 1 million operations have been used to create the risk calculators ***(Jacobs et al., 2014).***

Taking into consideration the patient's perioperative cardiac risk according to clinical predictors, functional capacity, and the extent of the future surgery, the anesthesiologist must decide whether further cardiac assessment or perioperative medical management are indicated. Patients whose functional capacity is difficult to establish, who underwent previous coronary revascularization, who have unstable or changed cardiac status, or who have severe comorbidities may need further evaluation. Several imaging techniques are available for evaluation of cardiac patients, including cardiac CT, coronary angiography, stress echocardiography, cardiac magnetic resonance imaging (CMRI), and myocardial nuclear studies ***(Kristensen et al., 2014).***

Aim Of The Work

To review all the recent guide lines in the anaesthetic management of patients with myocardial ischemia to provide the anesthesiologist with an understanding of the basics, clinical aspects and recent advances in the anaesthetic management of myocardial ischemia and in order to diminish cardiac-related mortality and to avoid adverse perioperative events.

Anatomy of the heart

Location of the Heart:

The human heart is located within the thoracic cavity, medially between the lungs in the space known as the mediastinum. Within the mediastinum, the heart is separated from the other mediastinal structures by a tough membrane known as the pericardium, or pericardial sac, and sits in its own space called the pericardial cavity. The dorsal surface of the heart lies near the bodies of the vertebrae, and its anterior surface sits deep to the sternum and costal cartilages. The great veins, the superior and inferior venae cavae, and the great arteries, the aorta and pulmonary trunk, are attached to the superior surface of the heart, called the base. The base of the heart is located at the level of the third costal cartilage. The inferior tip of the heart, the apex, lies just to the left of the sternum between the junction of the fourth and fifth ribs near their articulation with the costal cartilages. The right side of the heart is deflected anteriorly, and the left side is deflected posteriorly. The slight deviation of the apex to the left is reflected in a depression in the medial surface of the inferior lobe of the left lung, called the cardiac notch ***(Guyton et al., 2011).***

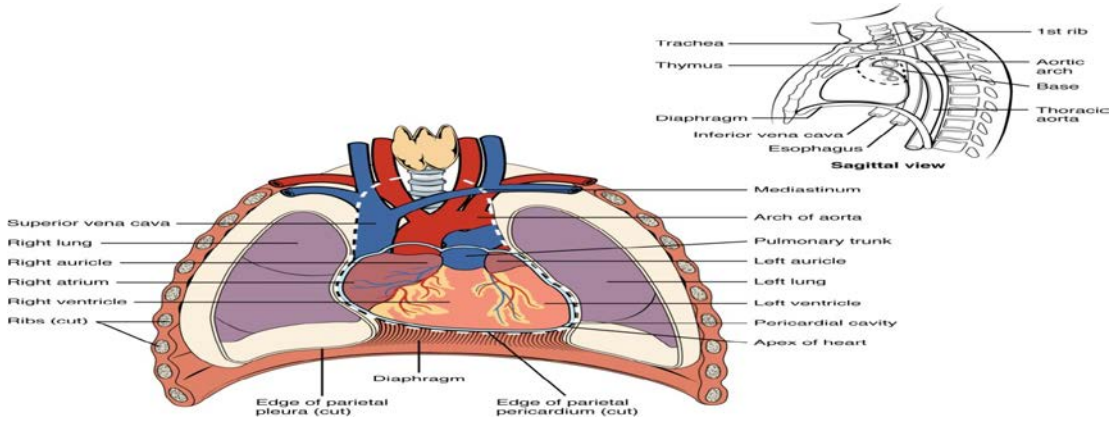

Figure 1: location of the heart ***(Guyton et al., 2011).***

Chambers and Circulation through the Heart:

The human heart consists of four chambers: The left side and the right side each have one atrium and one ventricle. Each of the upper chambers, the right atrium (plural = atria) and the left atrium, acts as a receiving chamber and contracts to push blood into the lower chambers, the right ventricle and the left ventricle. The ventricles serve as the primary pumping chambers of the heart, propelling blood to the lungs or to the rest of the body ***(Longo et al., 2011).***

There are two distinct but linked circuits in the human circulation called the pulmonary and systemic circuits. Although both circuits transport blood and everything it carries, we can initially view the circuits from the point of view of gases. The pulmonary circuit transports blood to and from the lungs, where it picks up oxygen and delivers carbon dioxide for exhalation. The systemic circuit transports oxygenated blood to virtually all of the tissues of the body and returns relatively deoxygenated blood and carbon dioxide to the heart to be sent back to the pulmonary circulation ***(Davidson et al., 2010).***

The right ventricle pumps deoxygenated blood into the pulmonary trunk, which leads toward the lungs and bifurcates into the left and right pulmonary arteries. These vessels in turn branch many times before reaching the pulmonary capillaries, where gas exchange occurs: Carbon dioxide exits the blood and oxygen enters. The pulmonary trunk arteries and their branches are the only arteries in the post-natal body that carry relatively deoxygenated blood. Highly oxygenated blood returning from the pulmonary capillaries in the lungs passes through a series of vessels that join together to form the pulmonary veins the only

post-natal veins in the body that carry highly oxygenated blood. The pulmonary veins conduct blood into the left atrium, which pumps the blood into the left ventricle, which in turn pumps oxygenated blood into the aorta and on to the many branches of the systemic circuit. Eventually, these vessels will lead to the systemic capillaries, where exchange with the tissue fluid and cells of the body occurs ***(Berry et al., 2010).***

In this case, oxygen and nutrients exit the systemic capillaries to be used by the cells in their metabolic processes, and carbon dioxide and waste products will enter the blood.The blood exiting the systemic capillaries is lower in oxygen concentration than when it entered. The capillaries will ultimately unite to form venules, joining to form ever-larger veins, eventually flowing into the two major systemic veins, the superior vena cava and the inferior vena cava, which return blood to the right atrium. The blood in the superior and inferior venae cavae flows into the right atrium, which pumps blood into the right ventricle. This process of blood circulation continues as long as the individual remains alive ***(Dorland et al., 2012).***

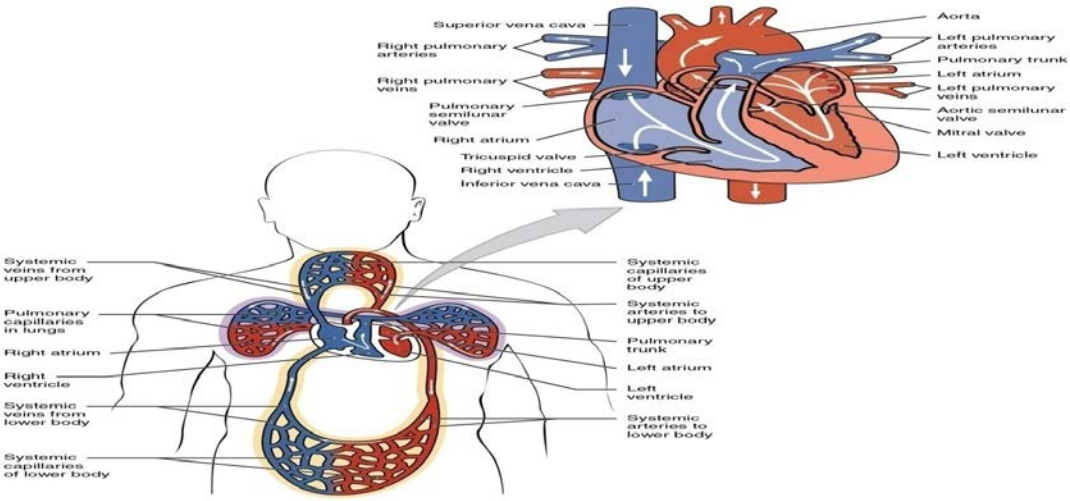

Figure 2 :Dual System of the Human Blood Circulation ***(Dorland et al., 2012).***

Layers of the heart:

The wall of the heart is composed of three layers of unequal thickness. From superficial to deep, these are the epicardium, the myocardium, and the endocardium. The outermost layer of the wall of the heart is also the innermost layer of the pericardium, the epicardium, or the visceral pericardium. The middle and thickest layer is the myocardium, made largely of cardiac muscle cells. It is built upon a framework of collagenous fibers, plus the blood vessels that supply the myocardium and the nerve fibers that help regulate the heart. It is the contraction of the myocardium that pumps blood through the heart and into the major arteries ***(Cantarini et al., 2014).***

The muscle pattern is elegant and complex, as the muscle cells swirl and spiral around the chambers of the heart. They form a figure 8 pattern around the atria and around the bases of the great vessels. Deeper ventricular muscles also form a figure 8 around the two ventricles and proceed toward the apex. More superficial layers of ventricular muscle wrap around both ventricles. This complex swirling pattern allows the heart to pump blood more effectively than a simple linear pattern would ***(Coven et al., 2016).***

Internal Structures of the Heart:

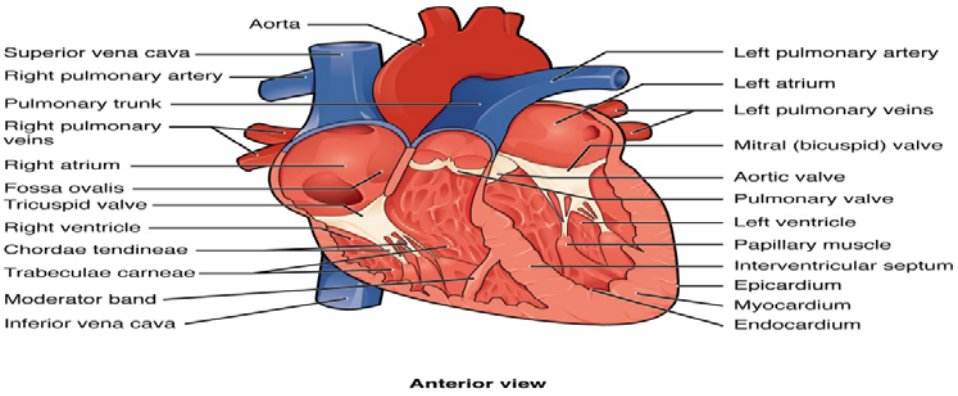

Figure 3: This anterior view of the heart shows the four chambers, the major vessels and their early branches, as well as the valves. The presence of the pulmonary trunk and aorta covers the interatrial septum, and the atrioventricular septum is cut away to show the atrioventricular valves ***(West et al., 2014).***

Heart Valve Structure and Function:

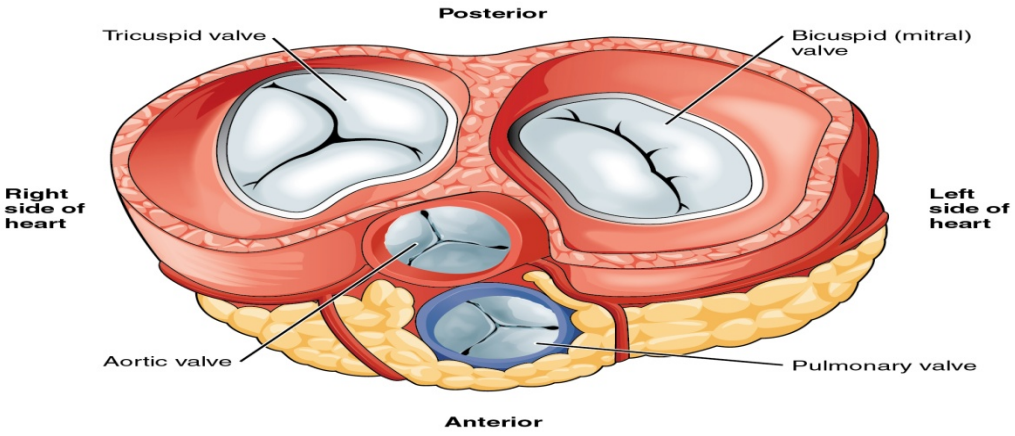

Figure 4 :A transverse section through the heart slightly above the level of the atrioventricular septum reveals all four heart valves along the same plane. The valves ensure unidirectional blood flow through the heart. Between the right atrium and the right ventricle is the right atrioventricular valve, or tricuspid valve. It typically consists of three flaps, or leaflets, made of endocardium reinforced with additional connective tissue. The flaps are connected by chordae tendineae to the papillary muscles, which control the opening and closing of the valves ***(Cooley et al., 2011).***

Emerging from the right ventricle at the base of the pulmonary trunk is the pulmonary semilunar valve, or the pulmonary valve; it is also known as the pulmonic valve or the right semilunar valve. The pulmonary valve is comprised of three small flaps of endothelium reinforced with connective tissue. When the ventricle relaxes, the pressure differential causes blood to flow back into the ventricle from the pulmonary trunk. This flow of blood fills the pocket-like flaps of the pulmonary valve, causing the valve to close and producing an audible sound. Unlike the atrioventricular valves, there are no papillary muscles or chordae tendineae associated with the pulmonary valve ***(Allen et al., 2014).***

Located at the opening between the left atrium and left ventricle is the mitral valve, also called the bicuspid valve or the left atrioventricular valve. Structurally, this valve consists of two cusps, known as the anterior medial cusp and the posterior medial cusp, compared to the three cusps of the tricuspid valve. In a clinical setting, the valve is referred to as the mitral valve, rather than the bicuspid valve. The two cusps of the mitral valve are attached by chordae tendineae to two papillary muscles that project from the wall of the ventricle.At the base of the aorta is the aortic semilunar valve, or the aortic valve, which prevents backflow from the aorta. It normally is composed of three flaps. When the ventricle relaxes and blood attempts to flow back into the ventricle from the aorta, blood will fill the cusps of the valve, causing it to close and producing an audible sound ***(Harrison et al., 2011).***

Coronary Circulation:

You will recall that the heart is a remarkable pump composed largely of cardiac muscle cells that are incredibly active throughout life. Like all other cells, a cardiomyocyte requires a reliable supply of oxygen and

nutrients, and a way to remove wastes, so it needs a dedicated, complex, and extensive coronary circulation. And because of the critical and nearly ceaseless activity of the heart throughout life, this need for a blood supply is even greater than for a typical cell. However, coronary circulation is not continuous; rather, it cycles, reaching a peak when the heart muscle is relaxed and nearly ceasing while it is contracting ***(Davidson et al., 2010).***

Coronary Arteries:

Coronary arteries supply blood to the myocardium and other components of the heart. The first portion of the aorta after it arises from the left ventricle gives rise to the coronary arteries. There are three dilations in the wall of the aorta just superior to the aortic semilunar valve. Two of these, the left posterior aortic sinus and anterior aortic sinus, give rise to the left and right coronary arteries, respectively. The third sinus, the right posterior aortic sinus, typically does not give rise to a vessel. Coronary vessel branches that remain on the surface of the artery and follow the sulci are called epicardial coronary arteries ***(Katz et al., 2008).***

The left coronary artery distributes blood to the left side of the heart, the left atrium and ventricle, and the interventricular septum.The circumflex artery arises from the left coronary artery and follows the coronary sulcus to the left. Eventually, it will fuse with the small branches of the right coronary artery. The larger anterior interventricular artery, also known as the left anterior descending artery (LAD), is the second major branch arising from the left coronary artery, it follows the anterior interventricular sulcus around the pulmonary trunk. Along the way it gives rise to numerous smaller branches that interconnect with the branches of the posterior interventricular artery, forming anastomoses. An

anastomosis is an area where vessels unite to form interconnections that normally allow blood to circulate to a region even if there may be partial blockage in another branch. The anastomoses in the heart are very small. Therefore, this ability is somewhat restricted in the heart so a coronary artery blockage often results in death of the cells (myocardial infarction) supplied by the particular vessel ***(Taber et al., 2009).***

The right coronary artery proceeds along the coronary sulcus and distributes blood to the right atrium, portions of both ventricles, and the heart conduction system. Normally, one or more marginal arteries arise from the right coronary artery inferior to the right atrium. The marginal arteries supply blood to the superficial portions of the right ventricle. On the posterior surface of the heart, the right coronary artery gives rise to the posterior interventricular artery, also known as the posterior descending artery. It runs along the posterior portion of the interventricular sulcus toward the apex of the heart, giving rise to branches that supply the interventricular septum and portions of both ventricles ***(Murray et al., 2013)***

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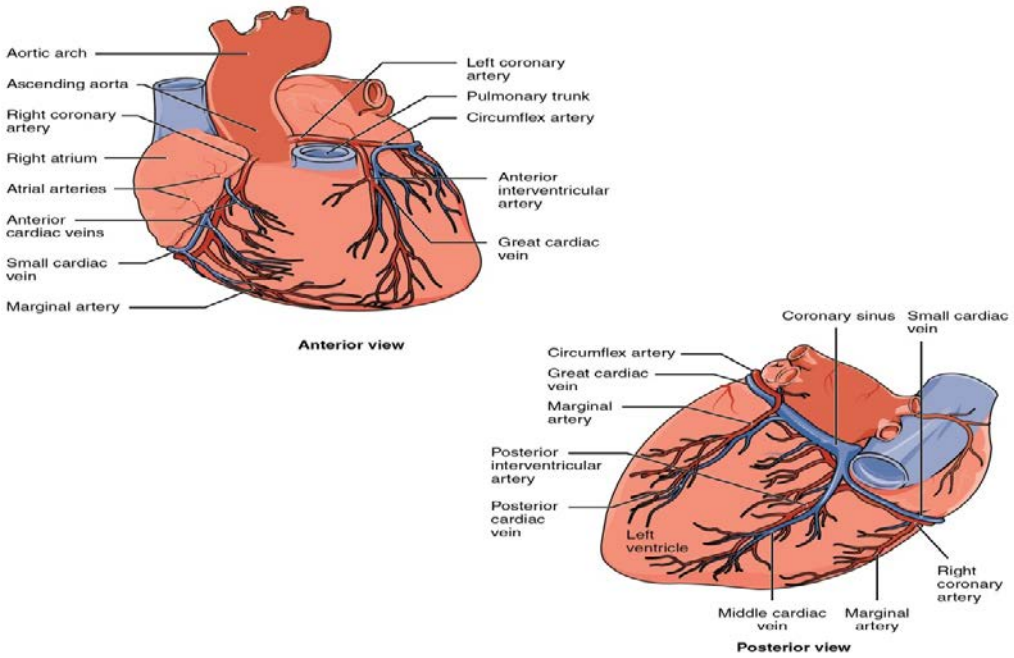

Figure 5: The anterior view of the heart shows the prominent coronary surface vessels. The posterior view of the heart shows the prominent coronary surface vessels ***(Jurd et al., 2004).***

Cardiac Physiology

The autorhythmicity inherent in cardiac cells keeps the heart beating at a regular pace; however, the heart is regulated by and responds to outside influences as well. Neural and endocrine controls are vital to the regulation of cardiac function. In addition, the heart is sensitive to several environmental factors, including electrolytes ***(Bianco et al., 2016).***

Resting Cardiac Output:

Cardiac output (CO) is a measurement of the amount of blood pumped by each ventricle in one minute. To calculate this value, multiply stroke volume (SV), the amount of blood pumped by each ventricle, by heart rate (HR), in contractions per minute (or beats per minute, bpm). It can be represented mathematically by the following equation: CO = HR × SV ***(Murray et al., 2013).***

SV is normally measured using an echocardiogram to record EDV (End diastolic volume) and ESV(End systolic volume), and calculating the difference: SV = EDV – ESV. SV can also be measured using a specialized catheter, but this is an invasive procedure and far more dangerous to the patient. A mean SV for a resting 70-kg (150-lb) individual would be approximately 70 mL. There are several important variables, including size of the heart, physical and mental condition of the individual, sex, contractility, duration of contraction, preload or EDV, and afterload or resistance. Normal range for SV would be 55–100 mL. An average resting HR would be approximately 75 bpm but could range from 60–100 in some individuals.Using these numbers, the mean CO is 5.25 L/min, with a range of 4.0–8.0 L/min. Remember, however, that these numbers refer to CO from each ventricle separately, not the total for the heart ***(Murray et al., 2013).***

Major Factors Influencing Cardiac Output:

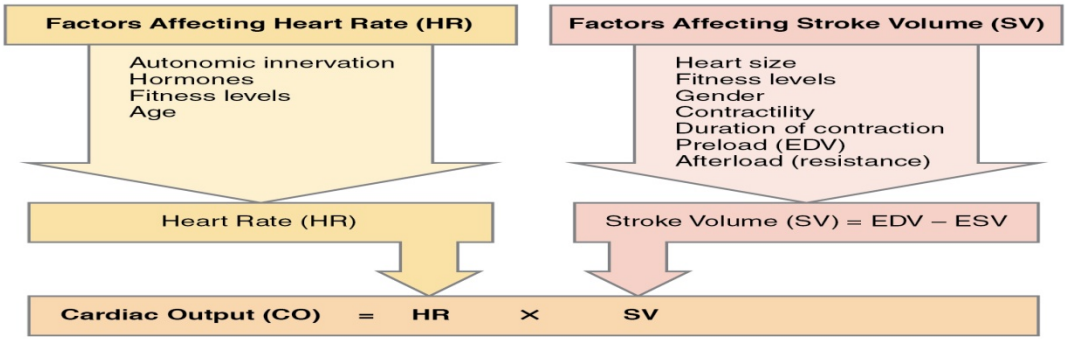

Figure 6: Cardiac output is influenced by heart rate and stroke volume, both of which are also variable (***Bianco et al., 2016).***

SVs are also used to calculate ejection fraction, which is the portion of the blood that is pumped or ejected from the heart with each contraction. To calculate ejection fraction, SV is divided by EDV. Despite the name, the ejection fraction is normally expressed as a

percentage. Ejection fractions range from approximately 55–70 percent, with a mean of 58 percent ***(Samia et al., 2010).***

Heart Rates:

HRs vary considerably, not only with exercise and fitness levels, but also with age. Newborn resting HRs may be 120 bpm. HR gradually decreases until young adulthood and then gradually increases again with age .Maximum HRs are normally in the range of 200–220 bpm, although there are some extreme cases in which they may reach higher levels. As one ages, the ability to generate maximum rates decreases. This may be estimated by taking the maximal value of 220 bpm and subtracting the individual's age. So, a 40-year-old individual would be expected to hit a maximum rate of approximately 180, and a 60-year-old person would achieve a HR of 160 ***(John et al., 2009).***

Initially, physiological conditions that cause HR to increase also trigger an increase in SV. During exercise, the rate of blood returning to the heart increases. However as the HR rises, there is less time spent in diastole and consequently less time for the ventricles to fill with blood. Even though there is less filling time, SV will initially remain high ***(Grimm et al., 2015).***

However, as HR continues to increase, SV gradually decreases due to decreased filling time. CO will initially stabilize as the increasing HR compensates for the decreasing SV, but at very high rates, CO will eventually decrease as increasing rates are no longer able to compensate for the decreasing SV. Consider this phenomenon in a healthy young individual. Initially, as HR increases from resting to approximately 120 bpm, CO will rise. As HR increases from 120 to 160 bpm, CO remains

stable, since the increase in rate is offset by decreasing ventricular filling time and, consequently, SV. As HR continues to rise above 160 bpm, CO actually decreases as SV falls faster than HR increases. So although aerobic exercises are critical to maintain the health of the heart, individuals are cautioned to monitor their HR to ensure they stay within the target heart rate range of between 120 and 160 bpm, so CO is maintained. The target HR is loosely defined as the range in which both the heart and lungs receive the maximum benefit from the aerobic workout and is dependent upon age ***(Grimm et al., 2015).***

Stroke Volume:

Many of the same factors that regulate HR also impact cardiac function by altering SV. While a number of variables are involved, SV is ultimately dependent upon the difference between EDV and ESV. The three primary factors to consider are preload, or the stretch on the ventricles prior to contraction; the contractility, or the force or strength of the contraction itself; and afterload, the force the ventricles must generate to pump blood against the resistance in the vessels ***(Colville et al., 2015).***

Preload:

Preload is another way of expressing EDV. Therefore, the greater the EDV is, the greater the preload is. One of the primary factors to consider is filling time, or the duration of ventricular diastole during which filling occurs. The more rapidly the heart contracts, the shorter the filling time becomes, and the lower the EDV and preload are. This effect can be partially overcome by increasing the second variable, contractility, and raising SV, but over time, the heart is unable to compensate for decreased filling time, and preload also decreases. With increasing

ventricular filling, both EDV or preload increase, and the cardiac muscle itself is stretched to a greater degree ***(Grimm et al., 2015).***

At rest, there is little stretch of the ventricular muscle, and the sarcomeres remain short. With increased ventricular filling, the ventricular muscle is increasingly stretched and the sarcomere length increases. As the sarcomeres reach their optimal lengths, they will contract more powerfully, because more of the myosin heads can bind to the actin on the thin filaments, forming cross bridges and increasing the strength of contraction and SV. If this process were to continue and the sarcomeres stretched beyond their optimal lengths, the force of contraction would decrease. However, due to the physical constraints of the location of the heart, this excessive stretch is not a concern ***(Farrell et al., 2011).***

The relationship between ventricular stretch and contraction has been stated in the well-known Frank-Starling mechanism or simply Starling's Law of the Heart. This principle states that, within physiological limits, the force of heart contraction is directly proportional to the initial length of the muscle fiber. This means that the greater the stretch of the ventricular muscle (within limits), the more powerful the contraction is, which in turn increases SV. Therefore, by increasing preload, you increase the second variable, contractility. ***Otto Frank*** (1865–1944), was a German physiologist; among his many published works are detailed studies of this important heart relationship. ***Ernest Starling*** (1866–1927), was an important English physiologist who also studied the heart. Although they worked largely independently, their combined efforts and similar conclusions have been recognized in the name "Frank-Starling mechanism." Any sympathetic stimulation to the

venous system will increase venous return to the heart, which contributes to ventricular filling, and EDV and preload.While much of the ventricular filling occurs while both atria and ventricles are in diastole, the contraction of the atria, the atrial kick, plays a crucial role by providing the last 20–30 percent of ventricular filling ***(Solomon et al., 2010).***

Contractility:

It is virtually impossible to consider preload or ESV without including an early mention of the concept of contractility. Indeed, the two parameters are intimately linked. Contractility refers to the force of the contraction of the heart muscle, which controls SV, and is the primary parameter for impacting ESV. The more forceful the contraction is, the greater the SV and smaller the ESV are. Less forceful contractions result in smaller SVs and larger ESVs. Factors that increase contractility are described as positive inotropic factors, and those that decrease contractility are described as negative inotropic factors (ino-= "fiber;" -tropic= "turning toward").Not surprisingly, sympathetic stimulation is a positive inotrope, whereas parasympathetic stimulation is a negative inotrope ***(Solomon et al., 2010).***

Sympathetic stimulation triggers the release of NE (Norepinephrine) at the neuromuscular junction from the cardiac nerves and also stimulates the adrenal cortex to secrete epinephrine and NE. In addition to their stimulatory effects on HR, they also bind to both alpha and beta receptors on the cardiac muscle cell membrane to increase metabolic rate and the force of contraction. This combination of actions has the net effect of increasing SV and leaving a smaller residual ESV in the ventricles. In comparison, parasympathetic stimulation releases ACh at the neuromuscular junction from the vagus nerve ***(Silverman et al., 2006).***

The membrane hyperpolarizes and inhibits contraction to decrease the strength of contraction and SV, and to raise ESV. Since parasympathetic fibers are more widespread in the atria than in the ventricles, the primary site of action is in the upper chambers. Parasympathetic stimulation in the atria decreases the atrial kick and reduces EDV, which decreases ventricular stretch and preload, thereby further limiting the force of ventricular contraction. Stronger parasympathetic stimulation also directly decreases the force of contraction of the ventricles ***(Davis et al., 2008).***

Several synthetic drugs, including dopamine and isoproterenol, have been developed that mimic the effects of epinephrine and NE by stimulating the influx of calcium ions from the extracellular fluid. Higher concentrations of intracellular calcium ions increase the strength of contraction. Excess calcium (hypercalcemia) also acts as a positive inotropic agent. The drug digitalis lowers HR and increases the strength of the contraction, acting as a positive inotropic agent by blocking the sequestering of calcium ions into the sarcoplasmic reticulum. This leads to higher intracellular calcium levels and greater strength of contraction. In addition to the catecholamines from the adrenal medulla, other hormones also demonstrate positive inotropic effects. These include thyroid hormones and glucagon from the pancreas. Negative inotropic agents include hypoxia, acidosis, hyperkalemia, and a variety of synthetic drugs ***(Davis et al., 2008).***

These include numerous beta blockers and calcium channel blockers. Early beta blocker drugs include propranolol and pronethalol, and are credited with revolutionizing treatment of cardiac patients experiencing angina pectoris. There is also a large class of dihydropyridine,

phenylalkylamine, and benzothiazepine calcium channel blockers that may be administered decreasing the strength of contraction and SV ***(Susan et al., 2008).***

Afterload:

Afterload refers to the tension that the ventricles must develop to pump blood effectively against the resistance in the vascular system. Any condition that increases resistance requires a greater afterload to force open the semilunar valves and pump the blood. Damage to the valves, such as stenosis, which makes them harder to open will also increase afterload. Any decrease in resistance decreases the afterload ***(Bondke et al., 2014).***

Determinants of Myocardial Oxygen Consumption:

Myocyte contraction is the primary factor determining myocardial oxygen consumption (MVO_2) above basal levels. Therefore, factors that enhance tension development by the cardiac muscle cells, the rate of tension development, or the number of tension generating cycles per unit time will increase MVO_2. For example, doubling heart rate approximately doubles MVO_2 because ventricular myocytes are generating twice the number of tension cycles per minute. Increasinginotropy also increases MVO_2 because the rate of tension development is increased as well as the magnitude of tension, both of which result in increased ATP hydrolysis and oxygen consumption. Increasing afterload, because it increases tension development, also increases MVO_2. Increasing preload (e.g., ventricular end-diastolic volume) also increases MVO_2; however, the increase is much less than

what might be expected because of the LaPlace relationship ***(Solomon et al., 2010).***

(Law of LaPlace) the LaPlace relationship says that wall tension (T) is proportional to the product of intraventricular pressure (P) and ventricular radius (r) ***(Farrell et al., 2011).***

Wall tension can be thought of as the tension generated by myocytes that results in a given intraventricular pressure at a particular ventricular radius. Therefore, when the ventricle needs to generate greater pressure, for example with increased afterload or inotropic stimulation, the wall tension is increased (i.e., increased myocyte tension development). This relationship also shows us that a dilated ventricle (as occurs in dilated cardiomyopathy) has to generate increased wall tension to produce the same intraventricular pressure ***(Farrell et al., 2011).***

Perioperative evaluation of cardiac patient

Scoring systems and risk indices:

These multi-variable analyses identify combinations of factors, generally based upon routine clinical information and laboratory tests, used to estimate the risk of cardiac complications.

The ideal scoring system would be:

- Simple to use.
- Highly sensitive.
- Highly specific high positive predictive value.
- Cheap and easily repeatable.

(Moreland & Adams, 2009).

1- American Society of Anesthesiologists (ASA) status:

This classification of physical status was originally introduced in 1941 with seven classes. It was revised to five classes in 1963.

In 1980, ASA PS class 6 was added (Table 1) to take into account the brain-stem-dead organ donor - patients that are already dead before entering theatre ***(Henry, 2011).***

Important points to note in the ASA classification that it stratifies patients by simple assessment of physical status with no expensive tests or clinical resources required, and there can be considerable observer variability of patients' physical status ***(Moreland & Adams, 2009)***.

Table (1): The 1980 ASA classification:

ASA class	*Definition*
I	Normal Healthy
II	Mild systemic disease
III	Severe systemic disease
IV	Severe systemic disease that is a constant threat to life.
V	Moribund patient - unlikely to survive 24 hrs with or without operation.
VI	Declared brain-dead patient whose organs are being removed for donor purposes
E	Suffix for patients undergoing emergency surgery

(Henry, 2011)

Wolters, 1996 investigated the ASA classification along with perioperative risk factors to see if any predictions could be drawn regarding postoperative outcome and complications.

Factors seen to correlate with increasing ASA class included:

- Intraoperative blood loss.
- Duration of operation.
- Duration of postoperative ventilation.
- Postoperative wound and urinary tract infections.
- Length of ICU and hospital stay.
- Rates of pulmonary and cardiac complications.
- In-hospital mortality. ***(Moreland & Adams, 2009)***.

The variables found to be most important for predicting complications were a high ASA class, having a major operation, and having an emergency operation. ***(Moreland & Adams, 2009)***.

2- Goldman's Cardiac Risk Index:

In the late 1970's, ***Goldman and colleagues*** took 1001 surgical patients and allocated a point value to 9 different clinical risk factors. Four risk classes were defined on the basis of the total points scored. The Goldman cardiac risk index is shown in Table 2 ***(Goldman et al., 1977)***.

Table (2): Goldman's Cardiac Risk Index:

Criteria		**Points**
History	- Age >70. -MI in previous 6 months.	5 10
Examination	-S3 gallop or jugular venous distension. -Important valvular aortic stenosis.	11 3
ECG	-Rhythm other than sinus or PACs. ->5 PVCs/min at any time before operation.	7 7
Markers of poor general medical condition (Kidney, lung, or liver disease, electrolyte imbalance, etc.)	-*p*O2 <60 or *p*CO2 >50mmHg. -K <3.0 or HCO3 <20 mmol/l. -BUN >50 or Cr >3mg/dl. -Abnormal AST (SGOT). -Signs of chronic liver disease. -Patient bedridden from non-cardiac causes.	3
Operation	-Intraperitoneal, intrathoracic, or aortic. -Emergency.	3 4
Total possible points		53

MI; Myocardial infarction, PACs; Premature atrial contractions, PVCs; Premature ventricular contractions, PO_2:Partial pressure of Oxygen, Pco_2;Partial pressure of Co_2, K; Potassium, HCo_3; Bicarbonate, AST; Aspartate transferase.***(Goldman et al., 1977).***

Patients in the lowest risk quartile (0 to 5 points) had less than a 1% risk of postoperative major cardiac complications. In the two middle quartiles with 6 to 25 points, the major cardiac event risk was 9%, and 22% of the patients in the highest risk group (≥26 points) had a major perioperative cardiac event ***(Goldman et al., 1977).***

Although this index is easy to use, it has some limitations:

- It was developed from data originating in the 1970's, and as such it does not reflect modern practice in anesthesia, medicine, or surgery.
- The study population contained few vascular patients, and as such its application to that subset of patients is unproven.
- The study group contained only elective cases.
- The index overestimated the incidence of cardiac morbidity in Class IV patients undergoing noncardiac surgery.
- The index underestimated the risk in Class I and II patients undergoing aortic surgery ***(Moreland & Adams, 2009)***.

3- Detsky's Cardiac Risk Index

A modified cardiac index that included a change in the scores allocated to risk factors such as type of operation, age, frequency of premature ventricular contractions, and aortic stenosis (AS) was published by ***Detsky*** in 1986. Heart failure was defined in this study as pulmonary edema determined by chest radiograph or by history of severe respiratory distress and resolution of the symptoms by use of diuretics. In addition, angina was subdivided into four classes according to the Canadian Cardiovascular Society classification. The score obtained from the patient's risk factors, along with the risk associated with the type of surgery, were used to calculate the probability of a cardiac event ***(Detsky et al., 1986).***

Since then, other authors have suggested the inclusion of further investigations, such as coronary perfusion scans or dobutamine stress echocardiography, as a means of improving the sensitivity and specificity of the test ***(Detsky et al., 1986)***.

4-Eagle's Cardiac Risk Index

One of the limitations of the Goldman criteria was the inability to predict the operative risk for patients undergoing vascular surgery because of the low number of such patients included in the original study population. This limitation was addressed by ***Eagle and colleagues*** in a study of patients undergoing vascular surgery. Multivariate analysis has shown that the following factors predict an adverse event following vascular surgery:

- Q waves on the electrocardiogram (ECG)
- History of angina pectoris

- History of ventricular ectopy requiring treatment (most specific for predicting events)
- DM requiring therapy other than diet
- Age older than 70 years
- Thallium redistribution (most sensitive for predicting events)
- Ischemic electrocardiographic changes during or after dipyridamole infusion ***(Eagle et al., 1989).***

Combining both the clinical data and thallium imaging was more sensitive and specific than either alone in predicting postoperative complications.

In this model, the following can be noted:

- No clinical predictors of risk factors: 3.1% risk of perioperative ischemic cardiac complications
- Thallium redistribution in addition to one or two clinical predictors: 29.6% risk of perioperative complications
- Three clinical predictors: 50% risk of perioperative cardiac complications ***(Eagle et al., 1989).***

5- Lee's Revised Cardiac Risk Index(RCRI):

The Modified cardiac risk index was revised by ***Lee*** in 1999. The revised index, looking at the risk of major cardiac complications, was derived from a population of 4000 patients undergoing nonemergency, noncardiac surgery ***(Lee et al., 1999)***.

Six independent predictors of major cardiac complications were used in combination to stratify patients into four classes as described in table 3 ***(Lee et al., 1999)***.

The rate of major cardiac complications (MI, pulmonary edema, ventricular fibrillation or primary cardiac arrest, or complete heart block) was assessed according to the number of predictors ***(Devereaux et al., 2005)***.

The advantages of this index over earlier scoring systems include:

- Only six prognostic factors are involved.
- Simple variables.
- Dependent on presence or absence of conditions rather than estimating disease severity.
- Less reliant on clinical judgment.
- Could easily be incorporated into preoperative evaluation forms.

The disadvantages of this system are:

- It is not applicable to emergency surgery.
- It is not applicable to lower-risk populations.
- It may not be as reliable for pre-selected high-risk populations, such as patients undergoing major vascular surgery ***(Moreland & Adams, 2009)***.

Table (3): Revised Goldman's Cardiac Risk Index(Lee's Risk Index):

Risk factors	Inclusion criteria
H/O of Ischemic heart disease	MI Q waves Angina Nitrates Positive exercise stress test
H/O of CHF	History Examination CXR
H/O of Cerebrovascular disease	Stroke TIA
Diabetes requiring insulin	
Creatinine	>2mg/dl
High-risk surgery	AAA repair Thoracic Abdominal

MI; Myocardial infarction, CHF; Congestive heart failure, CXR; Chest X-Ray, TIA; Transient ischemic attacks, AAA; Abdominal aortic aneurysm.

Revised Cardiac Risk Index	No. of factors	Proportion of population (%)	Major cardiac complications (%)
Class I	0	36	0.4
Class II	1	39	1.1
Class III	2	18	4.6
Class IV	3 or more	7	9.7

(Lee et al., 1999)

American College of Cardiologists /American Heart Association Guidelines (ACC/AHA):

In 2007, The American College of Cardiology (ACC) together with the American Heart Association (AHA) have divided markers of perioperative risks into two categories: active cardiac conditions and clinical risk factors . Patients presenting with active cardiac conditions generally will need extensive cardiovascular investigation and treatment, as well as postponement or cancellation of their elective surgery ***(Welten et al., 2007).***

Patients with clinical risk factors need careful assessment, weighed together with functional capacity and procedural risk, to decide on the need for noninvasive cardiac stress testing:

For patients with three or more clinical risk factors and poor (<4 metabolic equivalents) or unknown functional capacity, who require vascular surgery (emergency aortic and other major vascular surgery), it is reasonable to perform noninvasive stress testing if it will change management (class IIa).

- For patients with at least one clinical risk factor and poor or unknown functional capacity, who require intermediate-risk or vascular surgery, noninvasive stress testing may be considered if it will change management (class IIb).
- Noninvasive testing is not useful for patients with no clinical risk factors undergoing intermediate-risk noncardiac surgery (class III).
- Noninvasive testing is not useful for patients undergoing low-risk noncardiac surgery (class III) ***(Feringa et al., 2007).***

Table 4: ACC/AHA Perioperative Risk Assessment

Active Cardiac Conditions:
1-Unstable coronary syndromes
-Acute or recent myocardial infarction*
-Unstable or severe† angina (Canadian class III or IV)
2-Decompensated heart failure
3-Significant arrhythmias
-High-grade atrioventricular block
-Symptomatic ventricular arrhythmias in the presence of underlying heart disease
-Supraventricular arrhythmias with uncontrolled ventricular rate
4-Severe valvular disease
Clinical Risk Factors:
1-History of ischemic heart disease
2-History of cerebrovascular disease
3-Compensated or prior heart failure
4-Diabetes mellitus
5-Renal insufficiency

The American College of Cardiology National Database Library has defined recent myocardial infarction as >7 days but ≤1 month (30 days); acute myocardial infarction is within 7 days.May include "stable" angina in patients who are unusually sedentary ***(Brady et al., 2005).***

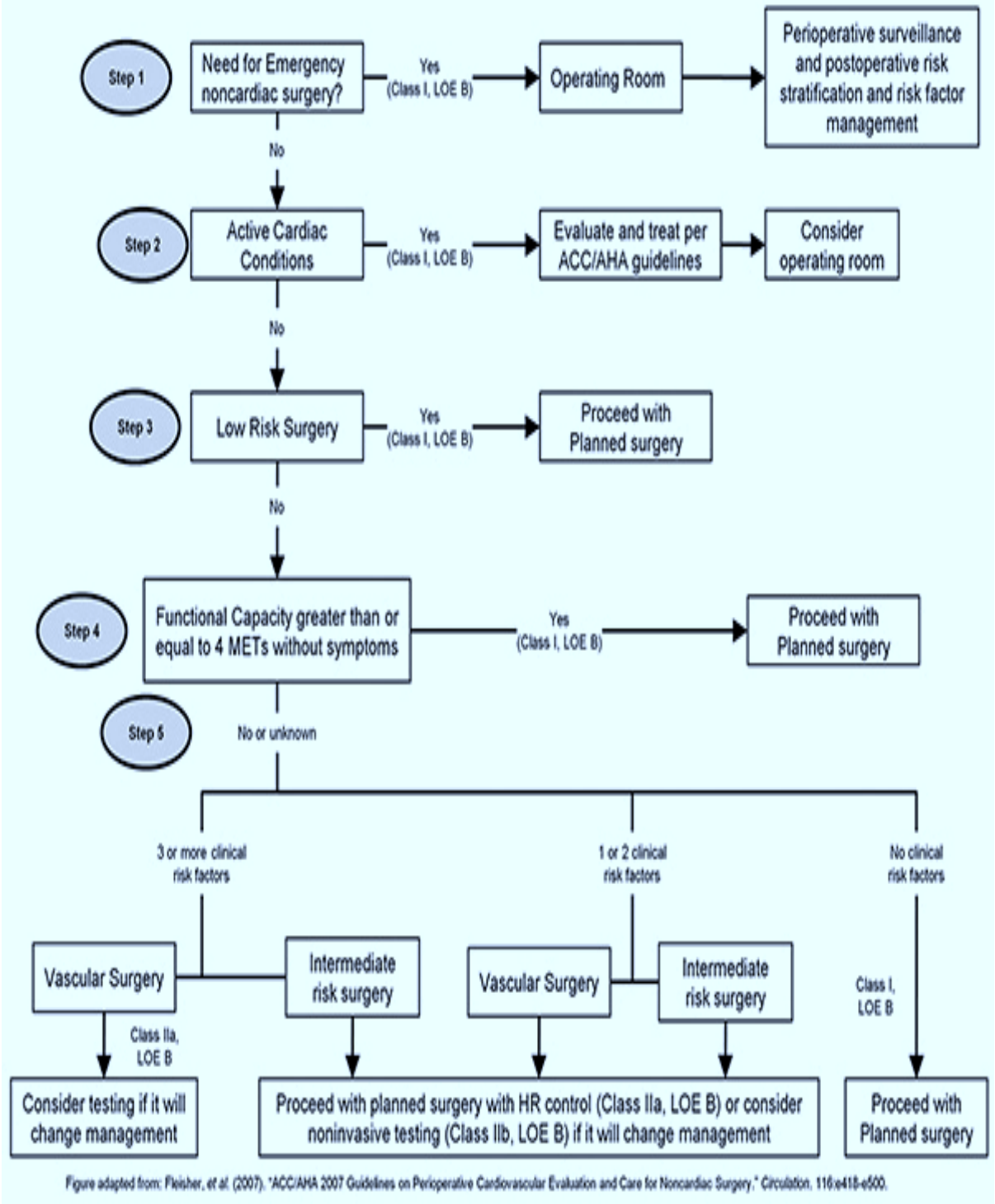

Figure adapted from: Fleisher, et al. (2007). "ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Care for Noncardiac Surgery." Circulation. 116:e418-e500.

Figure 7 :"ACC/AHA 2007 Guidelines on Perioperative Cardiovascular Evaluation and Carefor Noncardiac Surgery ***(Fliesher et al., 2007).***

ACC/AHA *2014 guidlines*, the guideline writing committee (GWC) of the ACC/AHA developed an algorithmic approach to perioperative cardiac assessment on the basis of the available evidence and expert opinion. The algorithm incorporates the perspectives of clinicians caring for the patient to provide informed consent and help guide perioperative management to minimize risk ***(Fleisher et al., 2014).***

It is also stated that it is crucial to incorporate the patient's perspective with regard to the assessment of the risk of surgery or alternative therapy and the risk of any medical therapy or coronary and valvular interventions before noncardiac surgery. Patients may elect to forgo a surgical intervention if the risk of perioperative morbidity and mortality is extremely high; soliciting this information from the patient before surgery is a key part of shared decision making ***(Fleisher et al., 2014).***

Various activity scales allow the clinician to determine a patient's functional capacity.Table5 shows METs (Metabolic equiveants)mappropriate for different levels of activities ***(Eagle et al., 2002)***.

Table (5): METs for different activities:

(1 MET)	• Can take care of self such as eat, dress or use toilet.
(4 METs)	• Can walk up a flight of steps or a hill.
(4-10 METs)	• Can do heavy work around the house, such as scrubbing floors or moving heavy furniture.
(>10 METs)	• Can participate in strenuous sports such as swimming, tennis, football, basketball and skiing.

(Eagle et al., 2002)

If a patient has not had a recent exercise test before noncardiac surgery, functional status can usually be estimated from activities of daily living. Functional capacity is often expressed in terms of metabolic equivalents (METs), where 1 MET is the resting or basal oxygen consumption of a 40-year-old, 70 kg man (Or 3.5 ml O_2 uptake/kg/min). In the perioperative literature, functional capacity is classified as excellent (>10 METs), good (7 METs to 10 METs), moderate (4 METs to 6 METs), poor (<4 METs), or unknown. Perioperative cardiac and long-term risks are increased in patients unable to perform 4 METs of work during daily activities ***(Poldermans et al., 1999).***

Examples of activities associated with <4 METs are slow ballroom dancing, golfing with a cart, playing a musical instrument, and walking at approximately 2 mph to 3 mph. Examples of activities associated with >4 METs are climbing a flight of stairs or walking up a hill, walking on level ground at 4 mph, and performing heavy work around the house ***(Poldermans et al., 1999).***

More accurate estimations of metabolic equivalents can be made from the Duke Activity Status index (DASI) in Table 6 ***(Nashef, 2004)***.

Table (6): The Duke Activity Status index:

Activity		Weight	MET value
Poor	-Walk indoors around the house. -Do light work around the house - strip and make a bed. -Take care of self - eating, dressing, and bathing.	1.75 2.70 2.75	<4
Intermediate	-Walk one or two blocks on the flat. -Do moderate housework sweeping, vacuuming or carrying shopping. -Do garden work - raking leaves, weeding or mowing the lawn. -Having sexual relations. -Climb a flight of stairs or walk uphill. -Play golf, bowling, dancing, and football.	2.75 3.5 4.5 5.25 5.5 6.0	4-7
Good	-Go swimming, play tennis, skiing. -Run a short distance at 5 mph. -Do heavy housework - scrubbing floors, lifting/moving heavy furniture.	7.5 8.0 8.0	>7

(Nashef, 2004).

Surgical Risk:

The type and timing of surgery significantly affects the risk of perioperative cardiac complications. The 2002 ACC/AHA guidelines stratify the risk by procedure as in table 7 ***(Eagle et al., 2002)***

Table (7): Grade of risk (with reported cardiac risk) with type of surgical procedure:

Low risk (<1%)	Intermediate risk (<5%)	High risk (>5%)
Endoscopic procedures	Carotid endarterectomy	Emergent major (particularly elderly)
Superficial procedures	Head and neck	Aortic and other major vascular surgery
Cataract surgery	Intraperitoneal and intrathoracic	Peripheral vascular
Breast surgery	Orthopaedic	Anticipated prolonged surgical procedures

Risk is for combined incidence of cardiac death and non-fatal MI ***(Eagle et al., 2002).***

Low-risk procedures are usually short, with minimal fluid shifts, while higher-risk operations tend to be prolonged with large fluid shifts and greater potential for postoperative myocardial ischemia and respiratory depression. Superficial and ophthalmologic procedures represent the lowest risk and are rarely associated with excess morbidity and mortality ***(Eagle et al., 2002).***

Emergency surgery is a special case as the necessity for immediate surgery precludes the time needed to fully evaluate and optimize these patients. The result is that cardiac complications are two to five times more likely to occur with emergency surgical procedures. For example, in asymptomatic elective abdominal aortic aneurysms repair, the mortality rate is 3.5% but this rises to 42% if ruptured ***(Eagle et al., 2002).***

General approach to the Patient

A-History:

The history should identify unstable coronary syndromes, prior angina, recent or past MI, significant arrhythmias and valve disease ***(Eagle et al., 2002).***

The functional capacity of the patient should be questioned. Functional status is a reliable predictor of perioperative and long-term cardiac events. Patients with reduced functional status preoperatively are at increased risk of complications. Conversely, those with good functional status preoperatively are at lower risk Moreover, in highly functional asymptomatic patients, it is Often appropriate to proceed with planned surgery without further cardiovascular testing ***(Poldermans et al., 1999).***

Another method of classifying functional capacity for those patients with known cardiac disease is the New York Heart Association (NYHA) classification as shown in Table 8 ***(American Heart Association, 1994)***.

Table (8): New York Heart Association (NYHA) classification:

Class	Description
I	Patients with cardiac disease but without resulting limitation of physical activity due to fatigue, palpitations, dyspnea or angina.
II	Patients with cardiac disease resulting in slight limitation in physical activity.
III	Patients with marked limitation of physical activity.
IV	Patients with cardiac disease who are unable to carry out any physical activity without discomfort. Symptoms of angina or heart failure may be present at rest.

Poor functional capacity may not necessarily have a cardiac cause. It may have a respiratory cause, or be caused by peripheral vascular disease or musculoskeletal disease, such as arthritis in the lower limbs ***(American Heart Association, 1994).***

The combination of good functional status, absence of known cardiovascular disease, and a low score on one of the multi-factorial risk indices questionnaires is associated with a very low rate of major complications even in patients undergoing major vascular surgery ***(American Heart Association, 1994)***.

B-Physical examination:

The examination of the cardiovascular system should include an assessment of vital signs (BP in both arms), carotid pulse contour and bruits, jugular venous pressure and pulsations, auscultation of the lungs, precordial auscultation and palpation, abdominal palpation and examination of the extremities for edema and vascular integrity. The presence of an implanted pacemaker or defibrillator should also be noted. ***(Moreland & Adams, 2009)***.

The history and physical examination are the most important aspects of assessing the patient's status and therefore risk. Further investigations or tests can be planned following the relevant findings ***(Moreland & Adams, 2009)***.

C- Clinical Predictors of Coronary Risk:

The ACC/AHA guideline summary describes clinical predictors of increased perioperative cardiovascular risk (MI, heart failure and death) ***(Eagle et al., 2002).***

- **Major predictors** that require intensive management and may lead to delay or cancellation of the operative procedure unless emergent are:

- Acute MI (within 7 days) in patients with evidence of important ischemic risk as determined by symptoms or noninvasive testing.
- Recent MI (within 8-30 days) in patients with evidence of important ischemic risk as determined by symptoms or noninvasive testing.
- Unstable angina.
- Severe angina; may include patients with stable angina who are usually sedentary.
- Decompensated heart failure.
- High-grade atrioventricular block.
- Symptomatic ventricular arrhythmias in patients who have underlying heart disease.
- Supraventricular arrhythmias with a poorly controlled ventricular rate.
- Severe heart valve disease

(Eagle et al., 2002).

Intermediate predictors that warrant careful assessment of current status are:

- Mild angina pectoris.
- Previous MI as determined from the history or the presence of pathologic Q waves.
- Compensated heart failure or a prior history of heart failure.

- Diabetes mellitus, particularly in patients who are insulin-dependent.
- Reduced renal function, which is defined as a serum creatinine > 2.0 mg/dl or a > 50% increase above normal baseline concentration.

(Eagle et al., 2002).

Minor predictors that have not been proven to independently increase perioperative risk. (Patients with minor predictors do not usually require any further noninvasive testing) are:

- Advanced age.
- Abnormal ECG (left ventricular hypertrophy, left bundle branch block, ST-T abnormalities).
- Rhythm other than sinus rhythm (e.g. atrial fibrillation).
- Low functional capacity (e.g. inability to climb one flight of stairs with a bag of shopping).
- History of stroke.
- Uncontrolled systolic hypertension ***(Eagle et al., 2002)***.

D-Surgical Risk:

Discussed in **Table (7):** Grade of risk (with reported cardiac risk) with type of surgical procedure.

E-Perioperative Medical Therapy:

A considerable number of studies have attempted to identify medications that could minimize the perioperative risk of patients undergoing noncardiac surgery. These studies involved beta blockers, lipid-lowering agents, clonidine, and other drugs (verapamil, diltiazem) ***(Chand et al., 2006).***

Beta Blockers

Several older studies showed a decreased incidence of death and MI during and after noncardiac surgery in patients who were given perioperative beta blockers. This benefit was most accentuated in patients who were intermediate- or high-risk. No benefit was found in low-risk patients. Some studies even reported harm from the use of beta blockers in low-risk populations. Other historical studies that started therapy hours before surgery did not find benefit from beta blockers. The benefit was mainly found in nonblinded studies such as the DECREASE family of trials, which titrated the dose of beta blockers over many days to a target heart rate close to 65 beats/min ***(Juul et al., 2006).***

In the more recent double-blinded, placebo-controlled, randomized POISE trial, patients received 100 mg metoprolol succinate or placebo 2 to 4 hours prior to their planned surgery, then continued to receive 100 to 200 mg long-acting metoprolol or placebo daily for 30 days after surgery. The results of POISE showed that, compared with those taking placebo, patients receiving metoprolol had fewer perioperative MIs. However, those taking metoprolol were also more likely to have a stroke, or to die. These findings led to a more conservative set of guidelines for perioperative beta blocker usage. Individuals who were already on beta blockers represented the only class I indication, mainly to avoid the

harmful effects of beta blocker withdrawal (tachycardia and hypertension). Beta blocker titration to heart rate and BP were "probably recommended" for patients undergoing vascular surgery who were at high cardiac risk due to CAD or ischemia on stress testing (class IIa), and they were "reasonable" for patients undergoing vascular surgery or intermediate-risk surgery with more than one clinical risk factor (class IIa) ***(Devereaux et al., 2008).***

In 2011, the validity of data from the DECREASE trials was called into question. As such, evidence supporting initiation of perioperative beta blockers has become even weaker. Unless future data can demonstrate a clear benefit for starting beta blockers perioperatively, our recommendation would be to give these drugs only to patients who have already been taking them at home, since a recent meta-analysis of nine secure trials found that the 30-day relative risk of all-cause mortality was 27% higher in patients treated with beta blockers, compared with those taking placebo ***(Fleischmann et al., 2009).***

Lipid-Lowering Agents (Statin):

The use of lipid-lowering agents has been advocated by some investigators as a possible means of reducing perioperative cardiac complications, presumably via atherosclerotic plaque stabilization. One retrospective study of patients undergoing vascular surgery found that statin use was associated with a reduced incidence of the composite end point (death, nonfatal MI, and ischemia). However, statin therapy was not associated with a statistically significant difference in nonfatal MI or death. This study was limited by a retrospective design and by nonspecified dose and duration of statins. Another observational study reviewed 780,000 records of adult patients who had undergone

noncardiac surgery, comparing those taking statins in the hospital to those who were not. With adjustment for baseline factors, patients on statin drugs had an in-hospital mortality rate of 2.18% versus 3.15% for those not on statins. This amounted to a statistically significant adjusted odds ratio of 0.62 for hospital mortality, favoring statin treatment ***(Lindenauer et al., 2004).***

At present, we do not have randomized controlled trial data to support preoperative initiation of statin drugs. By current ACC/AHA guidelines, the only class I indication for perioperative statin therapy is for those patients who were already taking statins at home. For patients undergoing vascular surgery, with or without clinical risk factors, perioperative statin use is felt to be "reasonable" (class IIa recommendation) ***(Bouri et al., 2013).***

Alpha-2 Adrenergic Agonists

The evidence for benefit of alpha-2 agonists in the perioperative setting has been shown in two meta-analyses and one randomized trial, in which it was found that clonidine given before noncardiac surgery reduced the incidence of perioperative ischemia and mortality. However, this benefit was found in only subgroup of patients (those undergoing vascular surgery) and not in others; thus, we cannot extrapolate the findings in this study to other surgical patients. Until evidence for benefit of starting this medication preoperatively has been established, we do not recommend using clonidine unless the patient had been taking it chronically. There exists a class IIb recommendation in the guidelines to consider use of alpha-2 agonists for perioperative control of hypertension in patients with known CAD or at least one clinical risk factor ***(Dernellis et al., 2006).***

Antiplatelet Therapy:

Aspirin is recommended as a lifelong therapy that should never be interrupted for patients with cardiovascular disease ***(McFalls et al., 2004).***

Types of stents:

There are currently five types of stents available:

- Dual Therapy Stent (DTS)
- Bioresorbable Vascular Scaffold (BVS)
- Bio-engineered Stent
- Drug Eluting Stent (DES)
- Bare Metal Stent (BMS)

(Spyropoulos et al., 2012).

Clopidogrel therapy is mandatory for six weeks after placement of bare-metal stents, three to six months after myocardial infarction, and at least 12 months after placement of drug-eluting stents and current AHA/ACC guidelines recommend discontinuing its use if clinically feasible at least 5 days prior to surgery. Because of the hypercoagulable state induced by surgery, early withdrawal of antiplatelet therapy for secondary prevention of cardiovascular disease increases the risk of postoperative myocardial infarction and death five- to 10-fold in stented patients who are on continuous dual antiplatelet therapy ***(McFalls et al., 2004).***

The shorter the time between revascularization and surgery, the higher the risk of adverse cardiac events. Elective surgery should be

postponed beyond these periods, whereas vital, semiurgent, or urgent operations should be performed under continued dual antiplatelet therapy. The risk of surgical hemorrhage is increased approximately 20 percent by aspirin or clopidogrel alone, and 50 percent by dual antiplatelet therapy. The present clinical data suggest that the risk of a cardiovascular event when stopping antiplatelet agents preoperatively is higher than the risk of surgical bleeding when continuing these drugs, except during surgery in a closed space (e.g., intracranial, posterior eye chamber) or surgeries associated with massive bleeding and difficult hemostasis ***(McFalls et al., 2004).***

Anticoagulants:

The management of anticoagulation in patients undergoing surgical procedures is challenging because interrupting anticoagulation for a procedure transiently increases the risk of thromboembolism. At the same time, surgery and invasive procedures have associated bleeding risks that are increased by the anticoagulant(s) administered for thromboembolism prevention. If the patient bleeds from the procedure, their anticoagulant may need to be discontinued for a longer period, resulting in a longer period of increased thromboembolic risk. A balance between reducing the risk of thromboembolism and preventing excessive bleeding must be reached for each patient ***(Spyropoulos et al., 2012).***

Additional issues relate to the specific anticoagulant used. For those taking a vitamin K antagonist (eg, warfarin), it takes several days until the anticoagulant effect is reduced and then reestablished perioperatively; the risks and benefits of "bridging" with a shorter acting agent, such as heparin, during this time are unclear. Recommendations are that bridging therapy should be handled as follows: day 5- last Vitamin K antagonists

(VKA) dose, day 4- no heparin, days 3 and 2- therapeutic subcutaneous low-molecular weight heparin (LMWH) twice daily, day 1- hospitalization and INR measuring, day 0- surgery . The newer direct oral anticoagulants (eg, direct thrombin inhibitor dabigatran, factor Xa inhibitors rivaroxaban, apixaban, edoxaban) have shorter half-lives, making them easier to discontinue and resume rapidly, but the direct factor Xa inhibitors lack a specific antidote, which raises concerns about treatment of bleeding and management of patients who require an urgent procedure ***(Bell et al., 2016).***

F-Noninvasive Tests to Stratify Cardiovascular Risk

1- 12-Lead electrocardiogram (ECG):

A resting ECG is a helpful baseline piece of information. It may show signs of acute ischemia or previous ischemia. Presence of Q waves, both extent and magnitude, are a crude estimate of LVH and a predictor of long-term mortality. LV hypertrophy or ST segment depression or elevation has been associated with increased incidence of cardiac complications. It may reveal an underlying conduction defect or arrhythmia ***(Crow et al., 1997)***.

Patients who should have an ECG are:

- Those with at least one risk factor, and are undergoing a vascular procedure.
- Those with a recent history of chest pain or an ischemic equivalent that is considered to be at intermediate or high risk and are scheduled for an intermediate to high-risk procedure.
- Asymptomatic patients with diabetes mellitus.

- Patients who have undergone previous coronary revascularization.
- Asymptomatic men above age 45 and asymptomatic women above age 55 who have two or more risk factors for atherosclerosis.
- May be reasonable in patients with one risk factor who are undergoing an intermediate risk operative procedure.
- Patients who have had prior hospital admission for cardiovascular disease ***(Crow et al., 1997)***.

2- Ambulatory electrocardiographic monitoring:

This allows a 24hrs monitor of the ECG, measuring the variables throughout the patient's daily routine. It can also be a way of capturing electrical evidence of transient or unpredictable symptoms. This is not a good test to further stratify a high-risk patient ***(Fleisher et al., 1995)***.

3- Stress testing:

Many patients with CAD will have a relatively normal looking resting 12-lead ECG. Maybe up to 50% of patients with single vessel CAD will have a normal looking ECG even whilst undergoing gentle to moderate exercise. However, it is how the heart behaves under stress that is much more important. What is the functional capacity of the heart? Just how ischemic does it become, and under what degree of stress does this occur? How well does the myocardium recover? These questions may be answered by putting the heart under some degree of stress in a controlled environment. There are a number of ways of achieving this effect ***(Chaitman ., 1986)***.

Patients who should be considered for stress testing are:

- Those with active cardiac conditions (ACS, CHF, arrhythmias, severe valve disease).

- Those having vascular surgery if they have 3 or more risk factors or if their functional capacity is reduced below 4 METs.

Those with 1 or 2 risk factors and poor functional capacity (less than 4 METs) who are due to undergo at least intermediate-risk surgery ***(Moreland & Adams, 2009)***.

There are a number of ways in which the heart can be put under stress, it depends on some patient factors and local resources as to which modality is used. Physical exercise is used if the patient is able and they have an ECG which is amenable to this form of study ***(Chaitman ., 1986)***.

Exercise stress testing:

The commonest form of exercise stress testing is on a treadmill. This is a standardized exercise test, gradually becoming more difficult over a period of time.The ECG and hemodynamic responses are analyzed. If the patient already has an abnormal ECG (e.g. left bundle branch block, LV hypertrophy with “strain” pattern, or digitalis effect) then it is difficult to interpret this test and an alternative method of assessing myocardial ischemia should be used. This test does, however, give a good estimation of the functional capacity of the patient ***(Chaitman ., 1986)***.

Becoming more popular is the cardiopulmonary exercise testing regime. This combines exercise, usually in the form of a bicycle to pedal, but it can be modified so patients can use their arms to perform the

exercise, especially so in patients with musculoskeletal limitations. This modality not only analyzes the ECG, but also utilizes spirometry and analyzes inspired and expired gases from the lungs. This gives us much more useful information than the standard treadmill test ***(Chaitman ., 1986)***.

Non-exercise Stress Testing:

The two commonest techniques in current practice are the dobutamine stress echocardiogram and the intravenous dipyridamole/adenosine myocardial perfusion imaging with both thallium-201 and technetium-99. When compared, these two modalities were both able to detect moderate-to-large defects, and these were the defects that predict postoperative MI and death ***(Beattie et al., 2006)***.

Dobutamine stress echocardiography has become the method of choice for pharmacological stress testing coupled with ultrasound imaging. This modality allows visualization of the myocardium under stressful conditions. Wall motion abnormalities can be directly observed and quantified in relation to the supplying blood vessels. Fixed and reversible defects are also visualized. Atropine may be incorporated to enhance the chronotropic effect. Studies have shown that wall motion abnormalities at low ischemic threshold and at less than 60% of maximum age-related heart rate is a predictor of adverse events in both the long and short term postoperatively ***(Beattie et al., 2006)***.

Radionuclide perfusion imaging shows areas of the myocardium with perfusion defects. It shows fixed defects and defects that appear when the myocardium is stressed. Fixed defects tend not to be predictive of untoward perioperative cardiac events, unlike reversible defects. Reversible defects of increasing size tend to predict increasing

perioperative risk. Fixed defects tend to be more likely to predict long-term cardiac events ***(Lette et al., 1992)***.

In those patients not seemed suitable for dobutamine stress transthoracic echocardiography, dobutamine stress magnetic resonance imaging has been used successfully to identify myocardial ischemia ***(Moreland & Adams ., 2009)***.

Patients that can be shown to have inducible myocardial ischemia are at a 20% risk of an adverse cardiac event compared to 2% in those who do not have inducible ischemia ***(Nagel et al., 1999)***. Approximately 15% of those patients tested by pharmacological stress testing of any form reveal a positive test ***(Fleisher al., 1995)***.

Echocardiography:

Echocardiography has become routinely used in the diagnosis, management, and follow-up of patients with any suspected or known heart diseases. It is one of the most widely used diagnostic tests in cardiology. It can provide a wealth of helpful information, including the size and shape of the heart (internal chamber size quantification), pumping capacity, and the location and extent of any tissue damage. An echocardiogram can also give physicians other estimates of heart function, such as a calculation of the cardiac output, ejection fraction, and diastolic function (how well the heart relaxes) ***(Batohi et al., 2014).***

Echocardiography can help detect cardiomyopathies, such as hypertrophic cardiomyopathy, dilated cardiomyopathy, and many others. The use of stress echocardiography may also help determine whether any chest pain or associated symptoms are related to heart disease. The biggest advantage to echocardiography is that it is not

invasive (does not involve breaking the skin or entering body cavities) and has no known risks or side effects ***(Douglas et al, 2011).***

Not only can an echocardiogram create ultrasound images of heart structures, but it can also produce accurate assessment of the blood flowing through the heart by Doppler echocardiography, using pulsed- or continuous-wave Doppler ultrasound. This allows assessment of both normal and abnormal blood flow through the heart. Color Doppler, as well as spectral Doppler, is used to visualize any abnormal communications between the left and right sides of the heart, any leaking of blood through the valves (valvular regurgitation), and estimate how well the valves open (or do not open in the case of valvular stenosis). The Doppler technique can also be used for tissue motion and velocity measurement, by tissue Doppler echocardiography ***(Batohi et al., 2014).***

G-Invasive Testing to Stratify Cardiovascular Risk

Coronary angiography is part of the preoperative investigations required by the cardiologist and the cardiothoracic surgeon when deciding what form of revascularization is indicated: angioplasty, stent insertion, or CABG ***(Mason et al., 1995)***.

This is an investigation usually reserved for the patients who have positive results from the above selection of investigations and are therefore, by definition, extremely high-risk for an adverse cardiac event ***(Mason et al., 1995)***.

H-Preoperative Revascularization:

Prophylactic coronary revascularization in patients with asymptomatic CAD before major noncardiac surgery has no benefit, whether by PCI or (CABG) ***(McFalls et al., 2004)***.

1- CABG (Coronary atrtery bypass graft):

Indications for CABG:

- Patients with stable angina who have significant left main coronary artery stenosis.
- Patients with stable angina who have 3 vessel disease. There is greater benefit if LVEF is < 0.5.
- Patients with stable angina who have 2 vessel disease with significant proximal LAD stenosis and either LVEF less than 0.5 or demonstrable ischemia on noninvasive testing.
- Patients with high-risk unstable angina or non-ST segment elevation MI.
- Patients with acute ST elevation MI.

In summary, patients who are found to have prognostic high-risk coronary anatomy and in whom long-term outcome would likely be improved by CABG should undergo revascularization prior to undergoing elective vascular surgery or intermediate- to high-risk noncardiac surgery ***(McFalls et al., 2004)***.

2-PCI (Percutaneus coronary intervention):

There is currently no proven benefit in performing prophylactic PCI in patients with Canadian Cardiovascular Society class III angina ***(Poldermans et al., 2007)***.

Preoperative PCI (angioplasty or stent insertion) should be limited to those who have unstable CAD who would be eligible for revascularization according to the ACC/AHA guidelines for PCI and CABG ***(Eagle et al., 2004)***.

In those patients where emergency noncardiac surgery was imminent, then balloon angioplasty or bare metal stenting should be considered ***(Smith et al., 2006)***.

Following balloon angioplasty the noncardiac surgery should be performed within 8 weeks as restenosis of the angioplasty site rates increase after that. However, having said that, performing the noncardiac surgery too soon after PCI may also is hazardous ***(McFalls et al., 2004)***.

Arterial recoil or acute thrombosis tends to occur in the first few hours to days following angioplasty. The recommended timing, therefore, for a noncardiac surgical procedure to be performed is 2-4 weeks ***(Smith et al., 2006)***.

Anesthetic Management of Cardiac Patients

Administering anesthesia to patients with preexisting cardiac disease is an interesting challenge. Most common cause of peri-operative morbidity and mortality in cardiac patients is IHD (Ischemic heart disease) ***(Hall & Owings, 2002)*.**

Care of these patients requires identification of risk factors, pre-operative evaluation and optimization, medical therapy, monitoring and the choice of appropriate anesthetic technique and drugs ***(Kaul & Tayal, 2007).***

Management depends upon the type of surgery whether emergency or elective. For emergency surgery, proceed for the surgery with medical management of cardiac ailment. For elective surgery perioperative management depends upon various clinical risk factors and surgery specific risk factors ***(Eagle et al., 2002).***

Preoperative management

Preoperative visit to the patient is very important. A good rapport should be made with the patient and written consent obtained. Patient should be informed about the risk of surgery and anesthesia ***(Kaul& Tayal, 2007).***

At risk patients need to be managed with pharmacologic and other perioperative interventions that can ameliorate perioperative cardiac events. Three therapeutic options are available before elective noncardiac surgery.-

1. Optimization of medical management

2.Revascularization by PCI

3. Revascularization by surgery (CABG)

However, it may not be necessary to intervent preoperatively (except for BB therapy or α-2 agonists) to improve perioperative outcome. BBs have been shown to be useful in reducing perioperative morbidity and mortality in high risk cardiac patients and preferably titrated to a HR of 50-60 beats/min. ***(London et al., 2004)***

α-2 agonists by virtue of their sympatholytic effects can be useful in patients where BBs are contraindicated. Nitroglycerine lowers LV end-diastolic pressure (LVEDP) by reducing preload. It improves collateral coronary flow and reduces systemic BP. Other agents like CCBs, ACE inhibitors, aspirin, insulin, and statins prove to be beneficial perioperatively. Coronary intervention should be guided by patient's cardiac condition (unstable angina, left main or equivalent CAD, three vessel disease, decreased LV function) and by the potential consequences of delaying the noncardiac surgery for recovery after coronary revascularization ***(Eagle et al., 2002)*.**

Anesthetic considerations

Premedication

In order to reduce the fear and anxiety of the patient, provide analgesia for painful interventions such as vascular cannulation before anesthetic induction and to provide amnesia to some degree, pharmacological interventions are used. These agents are also supposed to prevent the anginal episodes which are clinically silent preoperatively. Oral, intravenous (I.V) or intramuscular (I.M) benzodiazepines are the agents that are most frequently chosen ***(London et al., 2008***).

Agents and their dosages are selected depending on the patients' age and physiologic status. High doses are desirable for the patients with CAD, whereas low doses are more appropriate for patients with valvular diseases whose physiologic status is compensated with enhanced sympathetic tone ***(Liu et al., 2004).***

However, on arrival to the operating room (OR) the patients may receive further medications in case of inadequate sedation, prior to interventions planned before induction. The benefits of premedication should also be secured by proper conditions of the OR including temperature and verbal interaction with the patient ***(London et al., 2008).***

Most popular premedications

For anxiolysis and amnesia;

- Diazepam oral: 0.1-0.15 mg/kg
- Midazolam I.V: 1-2 mg

For analgesia;

- Morphine I.M: 0.1-0.15 mg/kg
- Fentanyl I.V: 50-75 µg

The anesthetist has an important role in preoperative administration of cardiovascular medications especially the anti-anginal medications, ensuring that these agents are ordered for morning with sips of water, as the anesthesiologist is a 'perioperative physician' ***(London et al., 2008).***

For Valvular heart patients

All the patients with valvular heart diseases undergoing non-cardiac surgery should get antibiotic prophylaxis to prevent IEC. AHA

recommends ampicillin, 2 g I.M or I.V plus gentamicin 1.5 mg/kg I.M or I.V 30 mins before procedure and 6 hrs later ampicillin 1 gm I.M or I.V. For patients allergic to penicillin,vancomycin 1gm I.V is recommended. For dental and endoscopic procedures, oral amoxicillin 2gmor cephalexin 2 gm or azithromycin 500 mg, 1 hr before the procedure is given. Use of oral anticoagulants in patients with mitral stenosis who have atrial fibrillation should be kept in mind ***(Kaul & Tayal, 2007).***

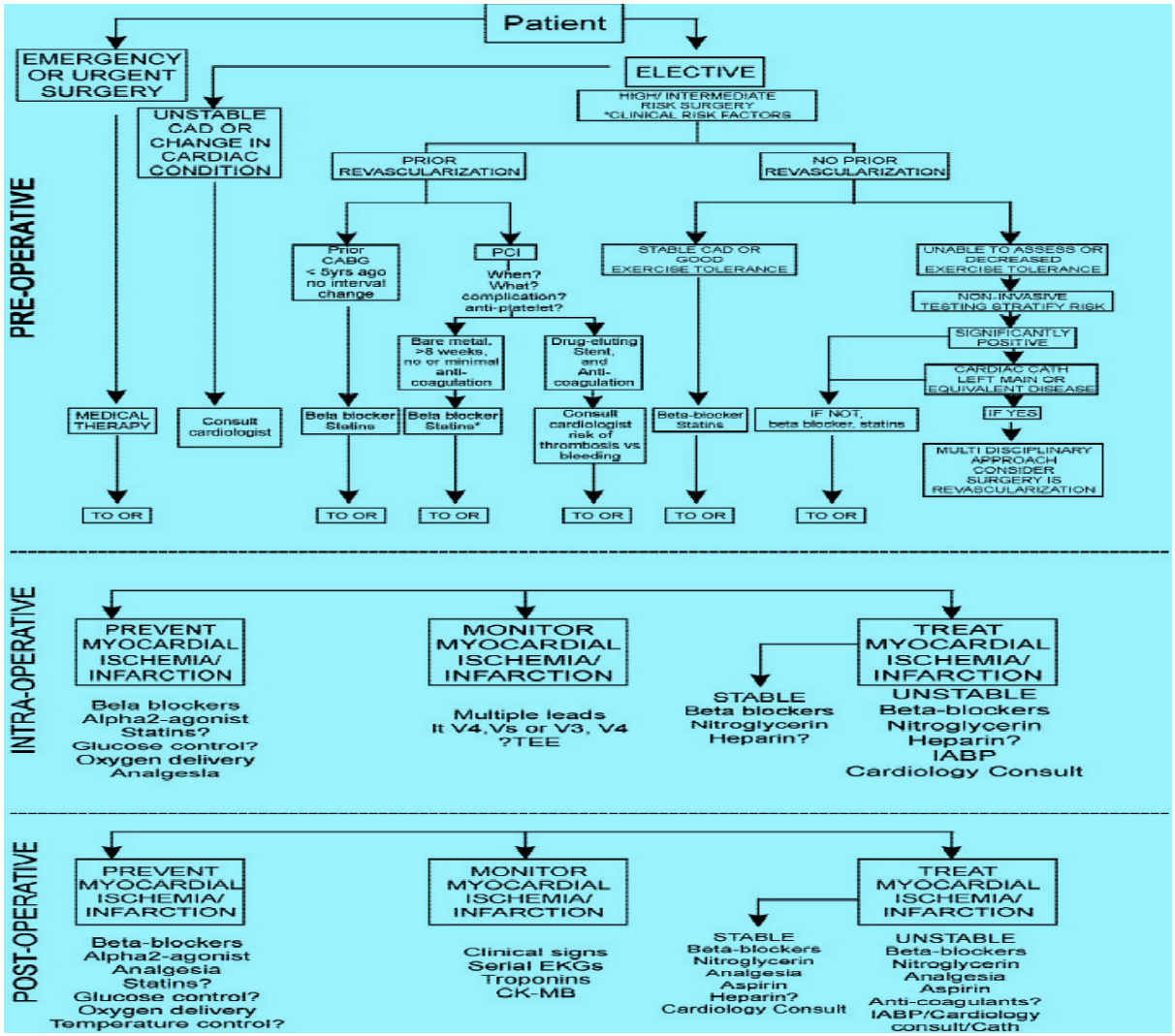

Figure8: The following algorithm helps in easy reference for planning perioperative management of cardiac patients undergoing noncardiac surgery(Kaul & Tayal**,** ***2007).***

Choice of anesthetics

The anesthesiologist should select the drugs with the objective of minimizing demand and optimizing supply of O_2. Along with the anesthetic agents some cardiac drugs should be readily available to maintain hemodynamics, to prevent and to treat ischemia, if it occurs ***(Kaul & Tayal, 2007).***

For valvular heart patients in general, the goal in stenotic lesions is to enhance forward flow, whereas in regurgitant lesions is to decrease regurgitant flow. Tachycardia is detrimental in both aortic and mitral stenosis. In MR and AR, it is advisable to maintain normal to high HR and mild vasodilatation to decrease the amount of regurgitant flow ***(Bonow et al., 1998).***

First:GeneralAnesthesia

Induction of Anesthesia

Anesthetic induction of cardiac surgical patients requires titration of drugs in order to avoid any increase in O_2 consumption and decrease in O_2 supply. Titration of induction agents with monitoring of the hemodynamics is more important than the type of the drug chosen ***(Barnes ., 2002).***

During induction, hypertension and tachycardia in patients with normal ventricular function, hypertension, and LV hypertrophy should be avoided, as well as hypotension and myocardial depression in patients with depressed ventricular function or stenosis. These agents should also provide smooth intubating conditions for those patients. These major concerns of cardiac anesthetic practice can be managed by using small doses of vasopressors for hypotension and by deepening anesthesia or

admininstering BBs for the hyperdynamic responses. In terms of intraoperative ischemia, postoperative MI or death, there is no single technique superior to others ***(London et al., 2008).***

There is no single strategy to be recommended for all cardiac surgical patients; hypnotics, opiods and volatile anesthetics are used in different combinations for both the induction and maintenance of anesthesia ***(London et al., 2008).***

1. Intravenous Anesthetics

Thiopentone: It reduces myocardial contractility, preload and BP and there is slight increase in HR. It should be administered slowly and with caution.

Propofol: It reduces arterial BP and HR significantly. There is dose dependent reduction in myocardial contractility. It can be used in patients with good ventricular function but is not a good induction agent for patients with CAD.

Ketamine: It is not good in IHD and valvular heart disease patients. It is however a useful agent in situations like cardiac tamponade and cyanotic heart disease.

Etomidate: It causes minimum hemodynamic changes. It is excellent for induction in patients with poor cardiac reserve ***(Kaul & Tayal, 2007).***

2. Narcotics

Morphine is the preferred drug for its relative cardiac stability and very good analgesic effect. It produces arterial and venous dilatation, resulting in reduction of afterload and preload. Newer narcotic analgesic

agents like fentanyl, alfentanyl and sufentanil also provide adequate cardiac stability and pain relief ***(Kaul & Tayal, 2007).***

3. Muscle Relaxants

All of the available neuromuscular blocking agents (NMBA) have been used for cardiac patients. Pancuronium offsetting the bradycardia effect of high-dose opioids has been the preferred NMBA, however it has also been shown to have potential to produce tachycardia causing myocardial ischemia during induction. Rocuronium has been compared with pancuronium and reported to provide more adequate conditions due to its less residual blockade and shorter time to extubation ***(London et al., 2008).***

Vecuronium produces minimum haemodynamic alterations and is short acting, therefore suitable for use in cardiac patients. Pipecuronium, mivacurium, doxacurium are newer non depolarizing muscle relaxants without any significant cardiovascular side effects ***(Kaul & Tayal, 2007).***

Maintenance of Anesthesia

Intravenous anesthetic agents

Combinations of opioids with benzodiazepines especially low doses of midazolam, because of its ease of use, low cost, hemodynamic stability and postoperative amnesia effects, have been used in order to overcome the adverse effects (***Stoelting & Hillier, 2006***).

However, some investigators believe that the combination of midazolam and opioids should be abandoned as general anesthetics; because they believe that this combination only provides general amnesia ***(Nagels, 2000***).

Midazolam has been used in combination with propofol and/or inhaled anesthetics, as well as opioids (***Stoelting & Hillier, 2006).***

Remifentanil provides stable hemodynamics in high-risk cardiac surgical patients. Remifentanil-propofol combination has been proven to be safe with stable hemodynamics, delivering an adequate depth of anesthesia ***(Lehmann et al., 2000).***

Sufentanil is a synthetic opioid, that has been used in combination with midazolam, propofol and inhaled anesthetics. Sufentanil combined with propofol has been shown to provide more stable hemodynamics when it is compared with fentanyl-based anesthetic protocols ***(Howie et al., 1991).***

Propofol has been used for maintenance of anesthesia in cardiac patients with reduced left ventricular function or with low cardiac output states in combination with opioids such as fentanyl, remifentanil, sufentanil or alfentanil ***(Bailey et al., 1996).***

In combination with ketamine propofol provides more stable hemodynamics than its combination with fentanyl ***(Stoelting & Hillier, 2006).***

Volatile anesthetic agents

The first clinical trial to investigate the clinical efficacy of the halogenated anesthetics was in 2002 reporting that sevoflurane preserves global hemodynamic and LV function with a lower postoperative troponin I compared with total IV anesthesia ***(Cannesson et al., 1997***).

Isoflurane is recommended in patients with good myocardial contractility. Halothane has the disadvantage of myocardial depression and potential of dysrrhythmias ***(Kaul & Tayal, 2007).***

Desflurane has also been shown to have cardioprotective effect in terms of ICU stay and weaning from mechanical ventilation.(***Christ et al., 2005)***

Second: Regional Anesthesia

The advantages of regional over general anesthesia should be an asset in cardiac patients if the surgery can be performed under regional block. Patient should be nicely premedicated without any apprehension ***(Breen & Park, 2002).***

Disadvantages of regional anesthesia include hypotension from uncontrolled sympathetic blockade and need for volume loading. Care should be taken with local anesthetic because larger doses can cause myocardial toxicity and depression. Use of epinephrine with local anesthetic is not recommended ***(Breen & Park, 2002).***

Specific Considerations for Valvular heart disease patients

Maintenance of hemodynamic stability in these patients can be quite challenging. General guidelines for hemodynamic management (heart rhythm, HR, preload, afterload, and contractility) will be presented for each of the four classic valvular lesions; AS, AR, MS and MR ***(Nussmeier et al., 2010).***

Aortic stenosis (AS):

AS is an important clinical entity because of the potential for sudden death and because of the relative ineffectiveness of external cardiac

massage during a cardiac arrest. The diagnosis of AS is made from a detailed history and physical examination, supplemented by echocardiography, which can be used to determine multiple aspects of the pathophysiology of the lesion ***(Mochizuki & Pandian ,2003).***

including the severity of AS, any structural abnormalities of the valve causing LV outflow tract (LVOT) obstruction, and any accompanying disease that can be found in the other heart valves. A commonly used parameter of severity is the aortic valve area (AVA), with normal AVA being 3-4 cm^2. In severe AS, AVA is $\leq$1 cm^2. Another parameter commonly used to determine the severity of AS is the gradient across the aortic valve, whereby AS is considered severe if the mean gradient is $\geq$ 40 mmHg ***(Mochizuki & Pandian ,2003).***

Operative risk depends upon the severity of the AS, whether the patient has concomitant coronary disease, and the risks of the surgical procedure ***(Sukernik & Martin ,2008).***

Anesthetic management of patients with AS revolves around avoiding fluctuations in the patient's hemodynamics, while achieving adequate anesthetic depth. Every effort should be made to ensure that the patient with AS stays in sinus rhythm. Due to diastolic dysfunction and impaired relaxation, the "atrial kick" may contribute as much as 40% of the total cardiac output. Anything interfering with atrial function (e.g., junctional rhythm or atrial fibrillation) can lead to severe hypotension. Therefore, in order to treat any possible arrhythmia, external cardioversion pads should be considered, preferably before induction of anesthesia ***(Sukernik & Martin ,2008).***

It is also important to avoid either tachycardia or bradycardia. Bradycardia is undesirable because the stroke volume is already limited

by the stenotic valve itself; therefore, cardiac output is unacceptably low in the presence of bradycardia. Tachycardia can usually be tolerated for short periods, but can further jeopardize an already compromised coronary supply/demand relationship in the presence of ventricular hypertrophy and concomitant coronary disease ***(Kertai et al., 2004).***

Preload should be maintained or increased in order to adequately fill the noncompliant LV. Afterload should be maintained or increased. Systemic hypotension causes reduced coronary perfusion pressure and should be managed with the early use of α-adrenergic agonists. Contractility should be maintained ***(Christ et al., 2005).***

Aortic Regurgitation (AR):

Echocardiography is the most important diagnostic tool. Regurgitant volume consisting of < 20% of the total LV stroke volume is considered mild, 20%-39% is considered moderate, 40%-60% is considered moderately severe, and > 60% is considered severe. In actuality, the regurgitant volume depends in part upon the diastolic time interval and the diastolic pressure gradient across the valve, as well as the regurgitant orifice area ***(Sukernik & Martin ,2008)***.

Maintaining a relatively fast HR (approximately 90 beats/min) will minimize the time spent in diastole and leads to a decreased regurgitant fraction. Sinus rhythm is preferable, but rapid supraventricular tachyarrhythmias are better tolerated in patients with AR than in patients with AS ***(Sukernik & Martin ,2008)***.

Also, due to the increased LV volume, preload should be augmented to maintain filling of the dilated LV and maintain forward flow. Furthermore, reducing afterload (maintaining a relatively low systemic

vascular resistance [SVR]) will minimize the pressure gradient back across the aortic valve during diastole, improving forward flow and decreasing LVEDP. Finally, LV contractility should be maintained ***(Sukernik & Martin ,2008)***.

In considering the choice of drugs for general anesthesia in these patients, medications that cause bradycardia should be avoided. Pharmacologic interventions that produce venous dilation may significantly impair cardiac output by reducing preload. Increases in ventricular afterload should be avoided. In some patients with AR, inodilator agents such as phosphodiesterase inhibitors or other intropic agents such as β-agonists may be needed to improve LV function ***(Sukernik & Martin ,2008)***.

Mitral stenosis (MS):

The normal mitral valve orifice area is approximately 4-5 cm^2. Symptoms of MS, usually dyspnea, can occur with a valve area less than 2.5 cm^2 and can be precipitated by clinical events associated with increased cardiac output and consequent increased flow across the stenotic valve, e.g., stress, exercise, anemia, pregnancy, or febrile illness. MS is considered to be mild if the valve area is 1.5-2.5 cm^2, moderate if 1.1-2.5 cm^2, and severe if $\leq$1.0 cm^2. Currently, MS is primarily diagnosed and monitored with echocardiography ***(Otto.,2004).***

The increased LA pressure in patients with MS gradually produces LA dilation. Such atrial enlargement can lead to the onset of atrial fibrillation and also to thromboembolic complications if a clot forms in the atrium or appendage due to low velocity blood flow. Treatment may include anticoagulation with IV heparin or oral coumadin, pharmacologic rate control, and pharmacologic or electrical cardioversion for

hemodynamically significant or acute onset atrial fibrillation. In patients scheduled for cardioversion, TEE (Trans tracheal echo) may be performed first to rule out the presence of LA thrombus ***(Messika et al., 2008).***

Primary concerns in patients with MS include management of HR, ventricular preload, potentially diminished right and left ventricular contractile function, and coexisting pulmonary hypertension. The most important hemodynamic goal is to avoid tachycardia (keep HR within its normal range). Tachycardia is poorly tolerated because of the decreased time for diastolic filling. Also, if possible, sinus rhythm should be preserved. Atrial contributions to stroke volume may be elevated in MS patients who are in the early stages of the disease and who are not in atrial fibrillation. Once atrial fibrillation has occurred, the atrial kick is lost. In this case, however, the most important factor in the deterioration of the patient's clinical condition is tachycardia itself, rather than loss of the atrial kick. In any event, digoxin should be continued perioperatively. Short-acting BBs can then be used for HR control ***(Messika et al., 2008).***

Flow through a stenotic mitral valve requires a higher-than-normal pressure gradient between the LA and the LV. Thus, reduction in preload, from the venodilator effects of anesthesia or from blood loss, can markedly affect cardiac output. In patients with MS, afterload reduction is usually not helpful in augmenting forward flow, because stroke volume is determined by the mitral valve orifice area and the diastolic filling interval ***(Messika et al., 2008).***

In patients with MS, oversedation in the preoperative period should be avoided to prevent hypoventilation. Bleeding complications from

chronic anticoagulation in patients with atrial fibrillation should be anticipated ***(Rahimtoola & Dell'Italia, 2004).***

Mitral regurgitation

MR is a commonly encountered valve lesion. The incompetent mitral valve allows retrograde passage of blood from the LV into the LA during systole. The magnitude of the regurgitant volume is a function of the size of the regurgitant orifice, the pressure difference between the LA and the LV, and the duration of the regurgitant cycle ***(Rahimtoola & Dell'Italia, 2004).***

The severity of MR is assessed in the context of whether the MR is acute or chronic. In patients with chronic MR, symptoms range from nonspecific complaints such as easy fatigability and palpitations to severe CHF. Echocardiography is used to serially follow patients with chronic MR. Quantitative estimates of regurgitant fraction (the fraction of regurgitant volume in relation to total stroke volume) are made from the LV angiogram or measured echocardiographically with Doppler. If regurgitant volume is< 30% of total LV stroke volume, the MR is considered mild, 30%-39% is considered moderate, 40%-60% is considered moderately severe, and > 60% is severe. Pulmonary venous systolic flow reversal is another indication that MR is severe ***(Sukernik & Martin, 2008)***.

Progressive LA enlargement eventually leads to atrial fibrillation, which occurs in about 50% of patients who present for surgical correction of MR ***(Sukernik & Martin, 2008)***.

With acute onset of MR (e.g., due to MI and rupture of papillary muscles), there has been no time for LA compensatory changes to occur.

Therefore, there is a sudden increase in LA pressure and PCWP. Patients with acute severe MR are usually in cardiogenic shock and do not present for noncardiac surgery. Pharmacologic support of the LV, often accompanied by mechanical support with intra-aortic balloon pump (IABP) counterpulsation, may be necessary to prepare the patient for emergency cardiac surgery ***(Borger et al., 2006).***

The primary goal in patients with chronic MR is maintaining forward systemic flow. The HR should be maintained in the high-normal range, i.e., 80 to 100 beats/min. Tachycardia decreases the regurgitant volume by shortening systole. Bradycardia has dual detrimental effects on MR: it increases the systolic period duration, thus prolonging regurgitation, and it increases the diastolic filling interval, which can lead to LV distention. A sinus rhythm is preferred, but there isless dependency on the atrial kick than in stenotic valvular heart disease ***(Nussmeier et al., 2010).***

As with most compensated forms of valvular heart disease, patients with hemodynamically significant MR are sensitive to ventricular loading conditions. It must be remembered that anesthetic effects on afterload and preload can drastically alter the severity of MR from its baseline level as seen in preoperative echocardiographic or catheterization assessments. In general, afterload reduction in combination with mild preload augmentation will enhance forward cardiac output and blood pressure. Adequate anesthetic depth, systemic vasodilators, or inodilators may be clinical options, depending on the situation. However, higher systolic driving pressures, as in hypertension, can increase the regurgitant volume, while fluid overload with ventricular distension can lead to expansion of an already dilated mitral annulus and thus worsen MR ***(Borger et al., 2006).***

Pulmonary artery pressures and PVR may be elevated in patients with MR. Factors that may increase PVR and unfavorably load an already dysfunctional RV, such as hypoxia, hypercarbia, and acidosis, should be avoided ***(Borger et al., 2006).***

Pain management

High dose opioids are given intraoperatively and analgesic effect continues in postoperative period. Good intraoperative and postoperative analgesia is associated with improved outcome. Morphine in the doses of 25 microgram/kg/hr will provide adequate analgesia and moderate sedation during postoperative period while additional sedatives are needed in intubated patients. Larger doses are needed in infants and young children basically due to high clearance. Fentanyl at the doses of 1-5 microgram/kg/hr. can be given instead to provide continuous analgesia but associated with less sedation then morphine. Nonopioid analgesics like acetaminophen and ketamine can also be used as an adjunct to opioid analgesia. Ketamine is given intravenously as a bolus or in the form of continuous infusion at the rate of 10 - 45 microgram/kg/min ***(Swiatnicka et al., 2009).***

For Heart Failure:

Anaesthesia in patients with heart failure In preparing for surgery, preoperative transthoracic echocardiography (TTE) is paramount in patients with known or suspected HF. It can give information regarding LFEF, LV and atrial volumes, heart valve function and diastolic function, and inferior vena cava diameter for assessing volume status, all of which are of use in approaching such a patient successfully. Routine pre-operative TTE should be performed in high-risk cardiac patients. Natriuretic peptides dosing in known or suspected patients with HF is of

significance also, as their levels correlate well with perioperative morbidity and mortality. ACEIs can be transiently discontinued in patients susceptible to hypotension, but all HF medicine should be reinstituted as soon as clinical conditions allow postoperatively. Diuretics are useful for patients with signs of congestion and digitalis can be added to patients remaining symptomatic despite on maximal treatment, especially in those with AF. Vasodilators, inotropes and inodilators are indicated in advanced stages of CHF or in patients with AHF ***(Kristensen et al., 2014).***

Current ESC guidelines on heart failure recommend that patients with CHF use optimal doses of ACEIs/ARBs, beta-blockers and aldosterone antagonists as primary strategies in patients with HF, in order to reduce morbidity and mortality (evidence-based heart failure medicine). All patients with HF who are scheduled for non-cardiac surgery are to be treated optimally according to these guidelines. HF-REF patients with LVEF <35% and left bundle branch block with QRS >120 ms should be evaluated for resynchronization therapy or implantable defibrillator placing. The principles of preoperative anesthetic management in patients with HF are synthesized in table 9. Specific considerations concerning patients with hypertrophic cardiomyopathy (HCM) and pulmonary heart disease (PHD) are shown in table 10**.** ***(Kristensen et al., 2014).***

Intraoperative use of inotropes is justifiable only in patients with low cardiac output. Perioperative circulatory assist device use is advised only in experienced centres. In patients with newly diagnosed severe systolic HF, it is recommended that medical therapy be optimal before attempting non-urgent non-cardiac surgery, and the proposed time interval for achieving that status is three months, during which LV function and

remodeling can improve. Rapid preoperative initiation of high doses of beta-blockers or ACEIs, without careful titration is not recommended, as it can increase the risk for intraoperative hemodynamic instability and hypontension ***(Kristensen et al., 2014).***

Table 9. Principles of anesthetic management in patients with HF

Preoperative	Continuing preoperative HF medication (except for aldosterone antagonists) ECG Recent echocardiography Diagnosing and correcting electrolyte dysturbances Premedication for reducing anxiety Disabling ICD and availability of external defibrillator

(Butler et al., 2013).

Table 10. Considerations concerning patients with hypertophic cardiomyiopathy (HCM) and pulmonary heart disease (PHD)

Patients with HCM	**Patients with PHD**
Aggressive correction of hypovloemia Avoid high-pressure mechanical ventilaton and PEEP Volatile agents, beta-blockers and calcium blockers are prefered for reducing contractility Hypotension is treated with an alfaadrenergic agonist Avoid drugs that increase risk of leftventricle outflow tract obstruction (digitalis, nitrates, vasodilator, cathecolamies).	Preoperative optimization is focused on controlling infection, reversal of bronchospasm, improving mucus drainage, hidrating and reversal of athelectasis. Adequate depth of anesthesia during induction to avoid bronchospasm. Volatile agents are prefered for bronchodilator effect. Avoid high dose opioids. Humidified anesthetic gases for preserving muco-ciliary function Avoid high motor block and decreased systemic vascular resistance in patients with fixed pulmonary hypertension .

(Maile et al., 2014).

For arrhythmia:

Cardiac arrhythmias during anaesthesia are common and almost benign, with the incidence ranging from 60 to 90%. Arrhythmias are one of several significant predictors for severe cardiovascular outcomes. It is essential, therefore, for the anaesthetist to evaluate patients at risk preoperatively with a careful history and to have an appropriate knowledge concerning the aetiology, electrophysiology, diagnosis, drug effects and treatment of arrhythmias ***(Thompson et al., 2004).***

In the normal heart, the sinoatrial node initiates rhythmic cardiac electrical activity by cells with intrinsic pacemaker activity. Sequential atrial and ventricular contractions result in an increased efficiency of the cardiac pumping mechanism, which, in turn, may be affected by arrhythmias. Cardiac arrhythmias are caused by altered automaticity or abnormal impulse propagation, which arise from a variety of factors such as electrolyte disorders, hypoxaemia, hypotension, drugs and other disorders. Patients with underlying heart disease are especially at risk. When there is evidence that a potentially dangerous arrhythmia exists, the patient who presents for elective surgery should be given additional examinations and treated before operation. Although implantable cardioverter defibrillators are now available, there have been reported failures of these devices ***(Park et al., 2011).***

In emergency situations, the anaesthetist must know how to treat suspected arrhythmias. Arrhythmias should be treated if they have haemodynamic consequences or if they are potentially dangerous. However, there is growing concern about the safety of antiarrhythmic drugs because these drugs have the potential to fail, increase the severity of arrhythmias or produce other circulatory imbalances. Thus it is

important to first eliminate all possible anaesthetic and surgical effects on arrhythmias. Once it is decided to treat an arrhythmic disorder, the available therapeutic approaches are either electrical or pharmacological. Patients with potentially dangerous arrhythmias during anaesthesia must be monitored postoperatively and adequate prophylactic treatment should be initiated under prolonged ECG control ***(Walsh et al., 2007).***

For hypertensive patients :

Hypertension is a frequently encountered abnormality in patients being prepared for surgical procedures. This condition complicates anesthetic and postoperative management, but careful monitoring and treatment allow hypertensive patients to tolerate surgery safely. Particular attention should be directed toward continuing antihypertensive medicine until the time of the surgical procedure or initiating treatment before it, monitoring the blood pressure frequently after the operation, and controlling postoperative hypertension with one of many parenteral agents available. The possibility of the presence of secondary hypertension and cardiovascular complications of hypertension should be considered during the preoperative assessment ***(Wright et al., 2013).***

Hypertension being present in 50 million Americans. It is thus frequently detected among patients undergoing preoperative evaluation for surgical procedures-in a quarter of instances in one study. Hypertension in these patients raises several concerns, including the propensity to have more difficult hemodynamic control during anesthesia, a perceived risk of increased intraoperative and postoperative cardiovascular events, difficulties with blood pressure management immediately after the procedure, and the fact that hypertension is a risk factor for the presence of other cardiovascular diseases that may be silent.

It is prudent, then, for physicians, surgeons, and anesthesiologists to carefully evaluate the finding of increased blood pressure in patients presenting for surgical procedures ***(James et al., 2011).***

Assessing Blood Pressure Physicians must first confirm that patients' hypertension actually exists. Patients may be anxious, fearful, in pain, or rushed during an initial evaluation, all of which can induce a "physiologic" increase in blood pressure not representing true hypertension. Generally a physician can determine this by putting the patient at ease with reassurance and a calm environment, relieving pain if it exists, allowing a period of time to pass, then repeating the blood pressure measurement. In addition, the long-term state of the blood pressure may be determined by reviewing the patient's medical records. In these ways, a patient initially thought to be hypertensive may be found to have a normal blood pressure. The basic principles of blood pressure measurement, such as the use of a proper-sized cuff, must not be forgotten ***(Choudhry et al., 2016).***

Although a patient found hypertensive only transiently on admission may not need specific antihypertensive therapy to be prepared for a surgical procedure, this finding alone does indicate a propensity to become hypertensive during anesthesia and surgical therapy and should alert those caring for the patient to be prepared for the possible need to treat excessive rises in blood pressure. Particularly for patients undergoing a serious surgical procedure, blood pressure is often monitored directly through an intra-arterial catheter beginning immediately before anesthesia and continuing into the early postoperative course. This ensures that rapid changes in the blood pressure are detected and obviates the possibility of inaccurate cuff measurements due to body habitus or upper extremity vascular rigidity ***(James et al., 2011).***

If a patient is found preoperatively to have a truly elevated blood pressure, possible risk from this can be considered in two phases-the anesthetic and the postoperative periods. It is not unusual for a patient undergoing anesthesia to have a fall in blood pressure during induction, followed by a pressor response and tachycardia with intubation, a stabilization of blood pressure and heart rate during anesthesia, and another rise in these measurements are exaggerated. This is most prominent in patients with untreated hypertension who are seen for surgical therapy, but to a lesser extent it also occurs in those whose blood pressure, though treated, remains uncontrolled ***(Choudhry et al., 2016).***

Although persons with effectively treated hypertension have blood pressure changes more similar to those with normal blood pressures they, too, may have problematic lability in pressure. These excessive swings in blood pressure and heart rate place a patient with coronary artery disease or left ventricular dysfunction at risk for ischemia or heart failure.' Indeed, hypertensive patients have shown an increased incidence of ST-segment depression during surgical procedures while electrocardiographically monitored. In addition, chronic hypertension resets cerebral circulatory autoregulation so that in these patients intraoperative and postoperative blood pressure reductions to otherwise benign levels may induce cerebral ischemia ***(James et al., 2014).***

Surgical Risk for Hypertensive Patients: These risks have led to a concern as to whether hypertensive patients should undergo elective surgical procedures. Fortunately, data available indicate that at least patients presenting with mild or moderate hypertension can safely undergo surgical procedures. In a landmark study of 1,001 patients undergoing noncardiac operations, preoperative evaluation detected 280 with current or past elevated blood pressures. Although several other

criteria predicted a perioperative cardiac event, in multivariate analysis, hypertension did not ***(Balick et al., 2011).***

Other studies have since confirmed this finding. Presumably the explanation for this favorable result, despite the possible risk from increased hemodynamic instability associated with hypertension, is that modern anesthetic skills and techniques allow an anesthesiologist to blunt the exaggerated hemodynamic swings of hypertensive patients and to detect evidence of ischemia or congestive failure early so that pharmacologic intervention can be used to reverse these processes. Obviously, it is important for the anesthesiologist to be aware of the patient's hypertension preoperatively so that adequate anesthetic planning can be done to ensure safety. As previously mentioned, patients with hypertension who undergo surgical procedures with their blood pressure controlled have less serious hemodynamic changes intraoperatively than patients with uncontrolled hypertension going into surgery ***(Balick et al., 2011).***

If the surgical procedure is elective, it should be postponed until medical management of the hypertension is effective and metabolic homeostasis has occurred, probably a few weeks. Blockade-in those expected to tolerate such therapy well-may offer a particular advantage in smoothing intraoperative hemodynamics. If medical, logistic, personal, or reimbursement concerns suggest that an operation proceed as originally scheduled, several studies have shown the efficacy of short-term (within hours before the operation) treatment of hypertension by intravenous blockade and by oral blockers and clonidine hydrochloride" in smoothkening and extubation ***(Balick et al., 2011).***

In a patient with hypertension, these changes are in the blood pressure and heart rate responses during anesthesia. Blockade also was shown to notably limit the magnitude of blood pressure rise during intubation and the amount of ischemic changes on electrocardiographic monitoring during a surgical procedure. This benefit likely also results from using other agents shown to smooth intraoperative hemodynamics, because excessive blood pressure and heart rate changes are the probable stimuli of most episodes of intraoperative ischemia ***(Kaplanet al., 2013).***

So patients with mild or moderate hypertension undergoing surgical procedures pose a risk of having increased blood pressure instability during anesthesia and ischemic complications postoperatively. This risk can be reduced by preoperative and postoperative medication, including continuing a patient's ongoing antihypertensive therapy until the time of an operation, then resuming it as soon as possible postoperatively, including the nonoral forms ***(Devereaux et al., 2008).***

For Anticoagulants

Anticoagulants remain the primary strategy for the prevention and treatment of thrombosis. Unfractionated heparin, low molecular weight heparin (LMWH), fondaparinux, and warfarin have been studied and employed extensively with direct thrombin inhibitors typically reserved for patients with complications or those requiring interventions. Novel oral anticoagulants have emerged from clinical development and are expected to replace older agents with their ease to use and more favorable pharmacodynamic profiles. Increasingly, anesthesiologists are being requested to anesthetize patients who are on some form of anticoagulants and hence it is important to have sound understanding of pharmacology,

dosing, monitoring, and toxicity of anticoagulants ***(Horlocker et al., 2010).***

Anticoagulants are commonly prescribed for patients at risk of arterial or venous thromboembolism. The most common indications are atrial fibrillation, venous thromboembolism, and presence of mechanical heart valves. Perioperative management of anticoagulant therapy poses a major problem. Rebound hypercoagulability may occur following abrupt cessation of anticoagulation, whereas perioperative anticoagulation increases the risk of bleeding for many invasive and surgical procedures. The consequences of hematoma formation following neuraxial blockade can be catastrophic for the patient and include permanent paraplegia ***(Gómez et al., 2014).***

Table 11: The drugs altering the hemostasis .

Class and mechanism of action	Example
Anticoagulants	
Vitamin K antagonists	Warfarin
	Dicumoral
Indirect thrombin inhibitors	Heparin
	Unfractionated heparin
	Low molecular weight heparin (enoxaparin, dalteparin, tinzaparin)
Direct thrombin inhibitors	Hirudin derivatives
	Desirudin, lepirudin, bivalirudin
	Argatroban
	Dabigatran
Factor Xa inhibitors	Fondaparinux
	Rivaroxaban
	Apixaban
	Edoxaban
	Betrixaban (in development)
Antiplatelet drugs	
COX inhibitors	Aspirin
	Nonsteroidal anti-inflammatory drugs
Thienopyridine derivatives	Clopidogrel
	Ticlopidine
	Prasugrel
	Ticagrelor
Platelet GPIIb/IIIa inhibitors	Abciximab
	Eptifibatide
	Tirofiban
Thrombolytic/fibrinolytic agents	
Tissue plasminogen activators	Streptokinase
	Urokinase
Recombinant tissue plasminogen activators	Alteplase

COX=Cyclooxygenase, GPIIb/IIIa=Glycoprotein IIb/IIIa

(Gogarten et al., 2010)

Warfarin

Warfarin, a coumarin derivative, acts by inhibiting Vitamin K synthesis and thereby limiting the coagulation factors (II, VII, IX, and X) that are dependent on Vitamin K for its production. It has oral bioavailability of 100%,warfarin is 99% protein bound, which means it is easily displaced by other highly protein-bound drugs. It is almost entirely metabolized in the liver, which exposes it to further drug interactions. The anticoagulant effect can be best measured by prothrombin time (PT) and international normalized ratio (INR). Warfarin is administered orally, and the dosage is based on the indication. Warfarin is started with the initial dose of 2–5 mg/day orally for 1–2 days and maintenance in the range of 2–10 mg once daily depending on the PT and INR values ***(Breivik et al., 2010).***

Anesthetic management

Anesthetic management of patients anticoagulated perioperatively with warfarin depends on dosage and timing of initiation of therapy. The PT and INR of patients on chronic oral anticoagulants requires 3–5 days to normalize after discontinuation of anticoagulant therapy. Warfarin is stopped 4–5 days preoperatively (±bridging therapy) and INR should be within reference range before initiation of regional anesthesia. Remove the indwelling neuraxial catheters when the INR is <1.5 to assure that adequate levels of Vitamin K-dependent factors are present. With INR >1.5 but <3 removal of neuraxial catheters should be done with caution and neurological status assessed until INR has been stabilized (levels <1.5). In patients with an INR >3.0, warfarin should be withheld/reduced with concurrent neuraxial/deep perineural catheters ***(Baglin ., 2013).***

Heparin

Heparin is a naturally occurring mucopolysaccharide with a molecular size of 5000–25,000 daltons. It exists in its unfractionated form or fractionated form (***Oranmore &Griffiths ., 2006).***

Unfractionated heparin

It is a mucopolysaccharide with an average molecular weight of 15,000–18,000 daltons. It acts by binding reversibly to antithrombin III, accelerating its action on coagulation factors XII, XI, X, IX, plasmin, and thrombin. It also inhibits platelet activation by fibrin ***(Li et al., 2015).***

Unfractionated heparin (UFH) is administered parenterally, both subcutaneous (S/C) for its prophylaxis and as a continuous intravenous (IV) infusion when used therapeutically. IV heparin is usually given as a bolus of 100 U/kg followed by approximately 1000 U/h titrated to achieve an activated partial thromboplastin time (aPTT) of 1.5–2.5 times the control ***(Li et al., 2015).***

The effect of heparin is reversed using protamine in the dose of 1 mg for 100 U of UFH. Six side effects include heparin-induced thrombocytopenia (HIT) and osteoporosis ***(Davis et al., 2013).***

Anesthetic management

Anesthetic management of patients receiving UFH should start with review of medical records to determine any concurrent medications that influence clotting mechanisms. There is no contraindication to regional anesthesia with 5000 units twice daily S/C UFH (prophylaxis). Risk of bleeding are reduced by delaying heparinization until block completion, but may be increased in debilitated patients following prolonged heparin

therapy. Safety of neuraxial/deep-peripheral nerve block (PNB) in those receiving UFH >10,000 U/day or twice daily dosing has not been determined, and thrice daily UFH can lead to increased risk of bleeding. ***(Davis et al., 2013)***

HIT can occur during administration, so it is recommended that patients receiving heparin for more than 4 days be assessed (i.e., platelet count) before deep-PNB/neuraxial blockade or catheter removal ***(Hirsh et al., 2008).***

A study conducted by Warkentin *et al.*, on 665 patients receiving S/C UFH or LMWH for thromboprophylaxis following hip surgery, reported 2.7% incidence of HIT in those receiving UFH and 0% in patients receiving LMWH. This study defined HIT as a decrease in the platelet count in the presence of antiplatelet antibodie ***(van veen et al., 2011)***

Intraoperative heparin anticoagulation during vascular surgery combined with neuraxial anesthesia is acceptable with the following:

- Avoiding neuraxial techniques in patients with coagulopathies
- Delaying heparinization for 1 h following nontraumatic needle placement
- Using concentration of local anesthetic that permits neurological evaluation
- Monitor patients postoperatively for evidence of neurodeficits
- Removing neuraxial catheter 2–4 h following last heparin dose

- Assessing coagulation status, then resume 1 h following catheter removal

- Occurrence of bloody/difficult neuraxial blockade in vascular surgery and plan for intraoperative heparin can increase bleeding risk. However, there is no data to support mandatory surgery cancellation. Therefore, risk-benefit decision should be conducted with the surgeon and

1. Using low-dose anticoagulation (5000 U) and delaying administration for 1–2 h

2. Avoiding full intraoperative heparin 6–12 h

3. Postponing surgery to the next day should be considered.

- At therapeutic doses, UFH should be interrupted at least 4 h before performing neuraxial procedures and/or removal of neuraxial catheter

- In situations of full anticoagulation (i.e., cardiac surgery), risk of hematoma is unknown when combined with neuraxial techniques. Therefore, if using neuraxial anesthesia during cardiac surgery, it is suggested to monitor neurologic function and select local anesthetic that minimize motor blockade to facilitate detection of neurodeficits ***(Narouze et al., 2015).***

Low molecular weight heparin

LMWH include dalteparin, enoxaparin, and tinzaparin. LMWH has an average molecular weight of 2000–10,000 daltons with a greater ability to inhibit factor Xa, than thrombin. It has a more predictable dose

response curve and is administered at fixed dose, based on total body weight ***(Eriksson et al., 2009).***

LMWH has 100% bioavailability and reaches peak levels 2–4 h after S/C administration. It has a half-life of 3–4 h, and is eliminated primarily via renal clearance, necessitating dose reduction in patients with renal insufficiency. Factor Xa levels are used to monitor the effects of LMWH; ideally, factor Xa levels should be obtained 4 h after the administration of LMWH ***(Levy et al., 2013).***

LMWH is indicated for thromboprophylaxis and treatment of DVT/pulmonary embolism, myocardial infarction. LMWH has been demonstrated to be efficacious as a bridge therapy for patients anticoagulated with warfarin including parturients, patients with prosthetic heart valves, or preexisting hypercoagulable condition ***(Vílchez et al., 2014).***

Properties of LMWH differ from UFH in the following ways:

1. Lack of monitoring of anticoagulant response (anti-Xa level not predictive of risk)
2. Prolonged elimination half-life
3. Anti-Xa activity present 12 h post injection
4. Unpredictable response to protamine ***(Naeshiro et al., 2015).***

Anesthetic management

There is increased risk of hematoma with concomitant use of hemostasis altering medications. Altered coagulation can occur with preoperative LMWH thromboprophylaxis, and it is recommended that

deep-PNB/neuraxial placement be delayed 10–12 h after the last dose. In patients receiving therapeutic LMWH, delay of 24 h (minimum) is recommended to ensure adequate hemostasis at the time of regional anesthesia ***(Tardy et al., 2013).***

It is not recommended to perform neuraxial/deep-PNB techniques in patients receiving LMWH 2 h preoperatively because needle placement would occur at peak anticoagulant activity ***(Naeshiro et al., 2015).***

Management of postoperative LMWH thromboprophylaxis and neuraxial/deep-PNB techniques is based upon:

1. Time to first postoperative dose
2. Total daily dose
3. Dosing schedule ***(Linnemann et al., 2010).***

Neuraxial/deep-PNB can be safely performed with LMWH single-daily dosing with first dose administered 6–8 h postoperatively after confirming adequate hemostasis and second dose not sooner than 24 h later. Catheters may be maintained, but should be removed at a minimum of 10–12 h following the last dose of LMWH and subsequent dosing at a minimum of 2 h after catheter removal. Additional hemostasis altering medications should be avoided ***(Weitz et al., 2008).***

Twice daily postoperative LMWH is associated with increased risk of hematoma formation, so first dose should be delayed postoperatively along with evidence of adequate hemostasis. Catheter should be removed before twice daily LMWH initiation, and subsequent dosing delayed 2 h postcatheter removal ***(Vílchez et al., 2014).***

Factor Xa Inhibitors

Fondaparinux

Fondaparinux is a synthetic pentasaccharide that has potent anticoagulant activity. It selectively inhibits factor Xa. It is licensed for use in thromboprophylaxis in medical patients and in patients undergoing major lower limb orthopedic surgery or abdominal surgery. After a single S/C injection, peak plasma concentration occurs after 2 h. The half-life is 17–21 h in healthy patients, but this may be significantly prolonged in renal impairment ***(Levy et al., 2013).***

Anesthetic management

The hematoma risk for patients receiving fondaparinux remains unknown, so management consensus statements are based on sustained and irreversible effects, dosing/timing. Therefore, until further experience becomes available, performing deep-PNB/neuraxial techniques should occur as single needle pass, avoidance of analgesic catheters, and avoiding regional anesthesia with therapeutic dosing. ***(Johnson et al., 2008).***

Recent ASRA and ESRA consensus indicates a 3–4 days interval before performing regional anesthesia procedures and then resuming medications 12–24 h postprocedure ***(Moon et al., 2009).***

Rivaroxaban

Rivaroxaban is an oral administered factor Xa inhibitor, with maximum effect 1–4 h, terminal elimination half-life of 5–9 h, administered once/day for thromboprophylaxis, first dose 6–8 h postsurgery, but antidote not available. Clinicians should adhere to

regulatory recommendations and label inserts, particularly in clinical situations associated with bleeding. The antithrombotic effect can be monitored with PT, aPTT, Heptest, all of which demonstrate linear dose effects. Investigations comparing rivaroxaban LMWH demonstrated similar efficacy and rates of bleeding. Rivaroxaban is cleared by liver, gut, and kidney, but clearance time can be prolonged in the elderly (13 h) secondary to decline of renal function (dose adjustment with renal insufficiency and contraindicated in liver disease) ***(Leese et al., 2000).***

Anesthetic management

Recently published interim update to ASRA anticoagulation and recent ESRA/world institute of pain consensus recommend an interval of 3 days before regional anesthesia and delaying drug administration 6 h postprocedure ***(Janssen et al., 2013).***

Apixaban

Apixaban is an orally administered reversible direct factor Xa inhibitor. It is rapidly absorbed, attaining peak concentration in 1–2 h elimination half-life of 10–15 h. Elimination is 25% renal and 75% hepatic/biliary with intestinal excretion ***(Gorog et al., 2013).***

Anesthetic management

An update to ASRA anticoagulation and recent consensus by ESRA, ASRA, and World Institute of Pain regarding apixaban and regional anesthesia suggest a 3–5-day interval between last apixaban dose and deep-PNB/neuraxial interventions. As experience with this agent is limited, along with wide-ranging pharmacokinetics of apixaban therapy, it is warranted to delay postprocedure administration by 6 h ***(DeVile et al, 2010).***

Danaparoid

Danaparoid is an indirect factor Xa inhibitor with coagulation effects through antithrombin-mediated inhibition of factor Xa. It is a glycosaminoglycan mixture containing 84% heparin sulfate, dermatan sulfate, and chondroitin sulfate resulting in 10% incidence of HIT. It has a long elimination half-life of 22 h that could be prolonged with renal insufficiency. There is no antidote, coagulation monitoring can be done by measuring anti-Xa activity. It cannot be hemofiltered, but can be removed using plasmapheresis. It is used as an alternative in patients with HIT ***(Benzon et al., 2013).***

Thrombin Inhibitors

Hirudins: Desirudin, lepirudin, and bivalirudin

These recombinant hirudins are first-generation direct thrombin inhibitors and are indicated for thromboprophylaxis (desirudin), prevention of DVT and pulmonary embolism after hip replacement,and DVT treatment in patients with HIT.They are administered by parenteral route, have an elimination half-life of 30 min to 3 h, can accumulate in renal insufficiency and should be monitored using aPTT and ecarin clotting time (ECT) ***(Gómez et al., 2014).***

Lepirudin has been associated with antibody formation (incidence 40%), delayed elimination, unpredictable and prolonged activity, as well as association with bleeding and anaphylaxis ***(Breivik et al., 2010).***

Anesthetic management

Administration of thrombin inhibitors with other antithrombotics should always be avoided. In those rare circumstances where regional

anesthesia would be planned, it is recommended to wait for a minimum of 8–10 h following the last dose, along with evidence of aPTT or ECT within normal limits before proceeding with needle puncture, and then waiting for at least 2–4 h postprocedure before next dosing. However, secondary to potential bleeding issues and route of administration, the trend with these agents have been replaced with factor Xa inhibitors or argatroban for acute HIT ***(Baglin ., 2013).***

Argatroban

It is intravenously administered reversible and a direct thrombin inhibitor approved for the management of acute HIT (type II). Advantages or uniqueness over other thrombin inhibitors includes its elimination through the liver (indication in compromising renal dysfunction) and short elimination half-life (35–40 min) that reveals normalization of aPTT in 2–4 h following discontinuation. However, dose reduction should be considered in critically ill patients and those with heart failure or impaired hepatic dysfunction ***(Li et al., 2015).***

Dabigatran

An oral inhibitor approved for thromboprophylaxis (similar efficacy to LMWH and warfarin without increased risk of bleeding). Dabigatran etexilate is a prodrug that specifically and reversibly inhibits both free and bound clot. The prodrug is absorbed from the gastrointestinal tract with a bioavailability of 5%.Once absorbed, it is converted by esterases into active metabolite, dabigatran. Plasma level peaks at 2 h. The half-life is 8 h after single dose and up to 17 h after multiple doses. Eighty percent of the drug is excreted unchanged by the kidneys; it is contraindicated in patients with renal failure. Dabigatran prolongs aPTT but its effect is not linear and reaches plateau at higher doses. However, the ECT and

thrombin time are particularly sensitive and display a linear dose response at therapeutic concentrations. Reversal of anticoagulant effect is theoretically possible through administration of recombinant factor VII a, although this has been attempted clinically. Indeed, product labeling suggests that dialysis can be considered for patients with significant bleeding with dabigatran. ***(Li et al., 2015).***

Anesthetic management

ASRA anticoagulation (2010) interim update and the published consensus by ASRA, ESRA, and World Institute of Pain suggests waiting 4–5 days from last administration before performing regional anesthesia, 6 days to initiate medication post-RA, and 6 h between removal of neuraxial catheter and the next dose ***(Gogarten et al., 2010).***

Thrombolytics/fibrinolytics

Thrombolytic agents act by converting plasminogen to the natural fibrinolytic agent plasmin. Plasmin lyses the clots by breaking down fibrinogen and fibrin contained in the clot. Clot lysis elevates fibrin split/degradation products. Thrombolytic therapy will maximally depress fibrinogen and plasminogen for 5 h following therapy and remain depressed for 27 h. ***(Baglin ., 2013)***

Anesthetic management

Original recommendations to initiate thrombolytic therapy was contraindicated within 10 days following neuraxial/deep-PNB procedures and surgery, but in a recent consensus statement by ASRA and ESRA, it was reduced to 2 day minimum and performing assessments every 2 h for neurological deficits. The 2 day minimum is based on prolonged plasminogen depression for 27 h **.*(Benzon et al., 2013).***

Definitive data are not available on when to discontinue these agents and safe time to neuraxial/deep-PNB placement which ranges from 24 h to 10 days,but it should be noted that clots are stable for 10 days postthrombolytic therapy. There are no recommendations for the removal of analgesic catheters for patients receiving fibrinolytic/thrombolytic medications, but fibrinogen levels can provide guidance on thrombolytic effect and timing of catheter removal ***(Gorog et al., 2013).***

For Antiplatelets

Aspirin and other nonsteroidal anti-inflammatory drugs when administered alone during perioperative period are not considered a contraindication to regional anesthesia. In patients on combination therapy with medication that affect coagulation, clinicians should be conscious about neuraxial and deep-PNB techniques due to increased risk of bleeding.Cyclooxygenase 2 inhibitors have shown minimal effect on platelet function, consider safe for patients receiving regional anesthesia, and without additive effects in the presence of anticoagulation therapy ***(Van et al., 2009).***

Thienopyridine derivatives include clopidogrel, prasugrel, and ticagrelor which act by inhibiting P2Y12 receptor. The use of aspirin and a P2Y12 receptor inhibitor, the so-called dual antiplatelet therapy (DAPT), has dramatically reduced atherothrombotic events in patients with acute coronary syndrome and those who undergo percutaneous coronary intervention (PCI). A minimum of 6 weeks DAPT after bare metal stent insertion and at least 12 months after drug-eluting stent placement is recommended to avoid thrombotic complications ***(Collet et al., 2014).***

Invasive procedures are occasionally considered for patients with coronary stents on DAPT. If at all possible, such procedures should be differed for at least 6 weeks in those with bare metal stents and 6 months in those with drug-eluting stents. If surgery cannot be delayed, consultation with a cardiologist is strongly recommended before any planned interruption of treatment. In these scenarios, PNBs or general anesthesia might be preferable ***(Savonitto et al., 2010)*** .

Platelet dysfunction is present for 5–7 days after discontinuation of clopidogrel and 10–14 days for ticlopidine. Prasugrel is a new thienopyridine which inhibits platelets more rapidly, more consistently, and to a greater extent than do standard and high doses of clopidogrel. The platelet aggregation normalizes in 7–9 days after discontinuation of prasugrel. ***(Savonitto et al., 2010)***

Glycoprotein IIb/IIIa (GPIIb/IIIa) receptor antagonist such as abciximab, eptifibatide, and tirofiban are primarily used in a management of acute coronary syndrome and PCI ***(Llau et al., 2009).***

Anesthetic management

Antiplatelet medication including thienopyridine derivatives and platelet GPIIb/IIIa antagonist can have diverse pharmacologic effects on coagulation and platelet function. Such variable differences cause difficulty when considering regional anesthesia, as there are no acceptable tests that will guide antiplatelet therapy. Therefore, preoperative assessment should search for health considerations that contribute to altered coagulation. Risk of hematoma formations with these drugs in combination with regional anesthesia is unknown. Therefore, management is based on labeling and surgical reviews ***(Kereiakes et al., 2008)***

Time between discontinuation of therapy and neuraxial/deep-PNB is 14 days for ticlopidine and 5–7 days for clopidogrel. If performing regional anesthesia is indicated before completing suggested time interval, then normalization of platelet function should be demonstrated ***(Grines et al., 2007).***

GPIIb/IIIa inhibitors exert an effect on platelet aggregation and time to normal platelet aggregation is 24–48 h for abciximab and 4–8 h for eptifibatide and tirofiban following discontinuation. GPIIb/IIIa antagonists are contraindicated within 4 weeks of surgery and patients need to be monitored neurologically if such medications are administered in the postoperative period subsequent to neuraxial/deep-PNB ***(Kereiakes et al., 2008).***

Table 12: The clinical guidelines and protocols are helpful in deciding the plan of anesthetic management tailored to each patient.

Drug	Recommendations
Warfarin	Discontinue chronic warfarin therapy 4-5 days before spinal procedure and evaluate INR. INR should be within the normal range at the time of procedure to ensure adequate levels of all Vitamin K-dependent factors. After operation, daily INR assessment with catheter removal occurring with INR - 1.5
LMWH	Delay procedure at least 12 h from the last dose of thromboprophylaxis LMWH dose. For "treatment" dosing of LMWH, at least 24 h should elapse before procedure. LMWH should not be administered within 24 h after the procedure. Indwelling epidural catheters should be maintained only with once daily dosing of LMWH and strict avoidance of additional hemostasis altering medications, including NSAIDs
Unfractionated subcutaneous heparin	There are no contraindications to a neuraxial procedure if total daily dose is 10,000 units. For higher dosing regimens, increase neurological monitoring and cautiously co-administer antiplatelet medications
Unfractionated intraveneous heparin	Delay needle/catheter placement 2-4 h after last dose, document normal aPTT. Heparin may be restarted 1 h after procedure. Sustained heparinization with an indwelling neuraxial catheter associated with increased risk; monitor neurological status aggressively
Dabigatran	Discontinue 7 days before procedure; for shorter time periods, document normal TT. First postoperative dose 24 h after needle placement and 6 h postcatheter removal (whichever is later)
Fondaparinux	Discontinue 3-4 days before regional anesthesia needle puncture or catheter manipulation. It is contraindicated for indwelling catheters. First postoperative dose 12 h after catheter removal
Rivaroxaban, apixaban	Discontinue 3 days before regional anesthesia needle puncture or catheter manipulation. First postoperative dose 6 h after needle placement or catheter manipulation (whichever is later)
Antiplatelet medications	No contraindications with aspirin or other NSAIDs. Thienopyridine derivatives (clopidogrel and prasugrel) should be discontinued clopidogrel 5-7 days, prasugrel 7 days, and ticlopidine 14 days before procedure. GPIIb/IIIa inhibitors should be discontinued to allow recovery of platelet function before procedure (8 h for tirofiban and eptifibatide, 24-48 h for abciximab)
Thrombolytics/ fibrinolytics	No data available to suggest a safe interval between procedure and initiation or discontinuation of these medications

INR=International normalized ratio, aPTT=Activated partial thromboplastin time, LMWH=Low molecular weight heparin, NSAIDs=Nonsteroidal anti-inflammatory drugs, GPIIb/IIIa=Glycoprotein IIb/IIIa, TT=Thromboplastin time

(Craft et al., 2004)

So the management of anticoagulants in the perioperative period is based on their pharmacokinetics and pharmacodynamic profile. Understanding clinical indications for the drugs will make an anesthesiologist more aware of the risks of discontinuation. Several NOACs offer oral routes of administration, simple dosing regimen, efficacy with less bleeding risks, reduced requirement for clinically monitoring. Due to safety concerns of bleeding risks, guidelines, and recommendations have been designed to reduce patient morbidity/mortality during regional anesthesia. Patient-specific factors and surgery-related issues should be considered to improve patient-oriented outcomes ***(Brilakis et al., 2007).***

Coronary stents:

Types of stents: there are currently five types of stents available:

- Dual Therapy Stent (DTS)
- Bioresorbable Vascular Scaffold (BVS)
- Bio-engineered Stent
- Drug Eluting Stent (DES)
- Bare Metal Stent (BMS)

(Spyropoulos et al., 2012).

The introduction of BMS significantly reduced the frequency of symptom recurrence and repeat procedures due to stent re-stenosis by comparison with angioplasty. However, the incidence of re-stenosis was still unacceptably high. This led to the development of DESs during the 1990s ***(Llau et al., 2009).***

The metal mesh of a DES is coated with a polymer that contains a potent anti- proliferative drug slowly released into the vessel wall over several weeks. Two main types exist: Taxus® stents release paclitaxel, an anti-tumour drug that inhibits microtubule formation during cell division. Cypher® stents elute sirolimus (rapamycin), a macrolide antibiotic that blocks progression from G1 to S phase of the cell cycle. Both DESs inhibit smooth muscle cell proliferation and migration of cells of the vessel media, preventing the formation of a neointima that commonly leads to stent re-stenosis. Overall re-stenosis rates for DESs are <2% compared with ~15% for BMS and 30–40% for balloon angioplasty ***(Rabbitts et al., 2008).***

The need for dual antiplatelet therapy:

During normal stent deployment, significant trauma and damage to the endothelium occur. Initially, thrombogenic struts of the stent are exposed to passing coronary blood, creating the risk of early stent thrombosis until the endothelium can re-grow. During this period of re-endothelialization, dual antiplatelet therapy (DAPT) in the form of aspirin and clopidogrel is needed. Patients with BMS are typically recommended to usually continue clopidogrel for a minimum of 6 weeks to allow for complete endothelial re-growth. Beyond this period, antiplatelet cover with aspirin is all that is usually necessary. In contrast, the anti-proliferative drugs released by DESs delay endothelial growth, requiring patients with DES insertion to take clopidogrel for a minimum of 12 months and sometimes longer for more complicated lesions. All patients with stents should continue to take aspirin for life ***(Van et al., 2009).***

Risk of non-cardiac surgery after stent insertion:

Non-cardiac surgery and most invasive procedures increase the risk of stent thrombosis, especially when the procedure is performed before endothelial re-growth is established. This occurs primarily because antiplatelet therapy is often discontinued in the perioperative period and because surgery creates a pro-thrombotic state, leading to most cases of stent thrombosis occurring in the immediate or early postoperative period ***(Brilakis et al., 2007).***

Delay between stent(s) insertion and surgery:

The risk of stent thrombosis is drastically reduced for BMS if surgery is performed >6 weeks after insertion. The optimal delay after DES implantation is less clear, but is likely to be at least 12 months during which DAPT must be maintained. Even beyond this period of high thrombotic risk, patients with DESs still have a greater likelihood of perioperative stent thrombosis, especially if PCI was complex, with numerous reports of very late thrombosis occurring after non-cardiac surgery ***(Metzler et al., 2008).***

Awareness of risk:

Anaesthetists and surgeons should be aware of the high risk of stent thrombosis in patients with coronary stents undergoing surgery. However, a Canadian survey of anaesthetists revealed that 63% were not aware of recommendations about the appropriate duration between stent placement and subsequent surgical procedures. In addition, one-third suggested no delay or a delay of only 1–2 weeks which is insufficient for BMS, and even more so for DESs ***(O'Gara et al., 2013).***

Perioperative management:

Balance between risk of bleeding vs stent thrombosis

If surgery cannot be delayed beyond a stent's high-risk period, a difficult balance must be struck between thrombosis prophylaxis and surgical bleeding. In situations of catastrophic haemorrhage requiring emergency surgery, only a platelet transfusion will reverse the actions of aspirin and clopidogrel. However, for semi-elective and urgent surgery, there is minimal evidence on how best to pharmacologically manage such patients through the perioperative period. An interdisciplinary discussion between surgeon, anaesthetist, intensivist, and cardiologist for each individual case is essential. Additional consideration should also be given to the relative consequences of thrombosis within an individual stent. For example, thrombotic stent occlusion of the left main or proximal left anterior descending coronary artery carries a much greater morbidity and mortality than a more distally placed stent in a smaller vessel ***(Howard et al., 2007)***

Risk of surgical bleeding:

The risks of surgical bleeding associated with continuing DAPT perioperatively depend on the likelihood of major haemorrhage and the potential morbidity of excessive postoperative bleeding, as a function of the site of surgery. Except for intracranial surgery and prostatectomy, low-dose aspirin increases neither the severity nor the mortality of bleeding complications. The effects of clopidogrel on bleeding in non-cardiac surgery cause greater concern: because thienopyridines have greater antiplatelet activity than salicylates, coupled with firm evidence of enhanced bleeding in post-CABG patients, the general opinion is that clopidogrel will markedly increase surgical bleeding and most

practitioners recommend stopping it before elective surgery. There is, however, contrasting evidence to support this view: one large study reported severe bleeding in up to a fifth of patients taking DAPT, whereas another suggested only a modest increase in postoperative bleeding. It is well established, however, that epidural and spinal anaesthesia is not recommended in patients taking clopidogrel. (***Savonitto et al ., 2010).***

Surgeons who are concerned about the risk of perioperative bleeding may need help balancing risks of haemorrhage against the benefits of continuing DAPT. Even for procedures with higher bleeding risk, if surgeons are informed that stent thrombosis leads to MI or death if DAPT is stopped, they can often be persuaded that the risks of thrombosis outweigh those of bleeding. This strategy, however, is not appropriate for patients in whom excess bleeding would be catastrophic, for example, bleeding in a closed cavity such as spinal or neurosurgery, surgery on the posterior segment of the eye, or transurethral prostatectomy. In this situation, antiplatelet agents such as clopidogrel should be stopped before surgery. Aspirin, however, should be continued wherever possible ***(Muñiz-Lozano et al., 2013).***

Bridging therapy:

In situations where clopidogrel must be stopped, bridging therapy may be used. This refers to the substitution of an irreversible antiplatelet agent with a reversible and short-acting anti-coagulant and/or antiplatelet drug to offer thrombosis prophylaxis during the perioperative period. Many bridging regimes have been suggested, with little definitive evidence for one over another. Examples include unfractionated heparin (UFH), subcutaneous injection of low-molecular-weight heparin, non-

steroidal anti-inflammatory drugs, and GPIIb/IIIa inhibitors. ***(Angiolillo et al., 2012).***

Heparin therapy alone is unlikely to protect against stent thrombosis, as it has no antiplatelet properties. It makes more pharmacological sense to replace the thienopyridine with a short-acting, reversible antiplatelet agent. One possibility reported by Savonitto and colleagues is to start an infusion of tirofiban 4 days before operation (having discontinued clopidogrel the day before), maintained until 4 h before surgery. The patient is then re-loaded with clopidogrel on the first postoperative day; aspirin is continued throughout. If there is bleeding concern in the immediate postoperative period, tirofiban can be resumed and clopidogrel loading delayed until deemed safe to do so***(Capodanno et al., 2013).***

Although there is limited evidence and no licence for GPIIb/IIIa inhibitors in this setting, at present, these are the only reversible inhibitors of platelet activity that offer a logical short-acting substitute for the prevention of stent thrombosis. However, admitting patients well before surgery is expensive and often logistically difficult. Furthermore, this strategy may not offer complete protection, since the greatest risk of stent thrombosis is actually during or soon after surgery. More data are therefore needed ***(Capodanno et al., 2013)***

A summary of suggested pharmacological management of antiplatelet agents during the perioperative period is shown below:

i. Low bleeding risk. Maintain DAPT.

ii. Moderate bleeding risk. Maintain DAPT if possible, unless surgical bleeding risk outweighs thrombosis risk. Consider bridging therapy if clopidogrel must be stopped.

iii. High bleeding risk. Stop clopidogrel 5 days before surgery, and start bridging therapy 4 days before operation. Maintain aspirin wherever possible ***(Muñiz-Lozano et al., 2013).***

Use of thromboelastography as an adjunct to bridging therapy:

This whole-blood coagulation monitor is used increasingly as a point-of-care dynamic test of haemostasis. The maximum amplitude (MA) of conventional thromboelastography (TEG®) is not senstive enough to detect the presence of thienopyridines or salicylates. However, it may be used to monitor the antiplatelet effects of GPIIb/IIIa inhibitors. One possible strategy is the titration of a tirofiban infusion against a pre-determined target MA, agreed upon by considering a patient's relative risk of stent thrombosis *vs* surgical bleeding, similar to titrating the APTT in UFH infusions ***(Valgimigli ., 2014).***

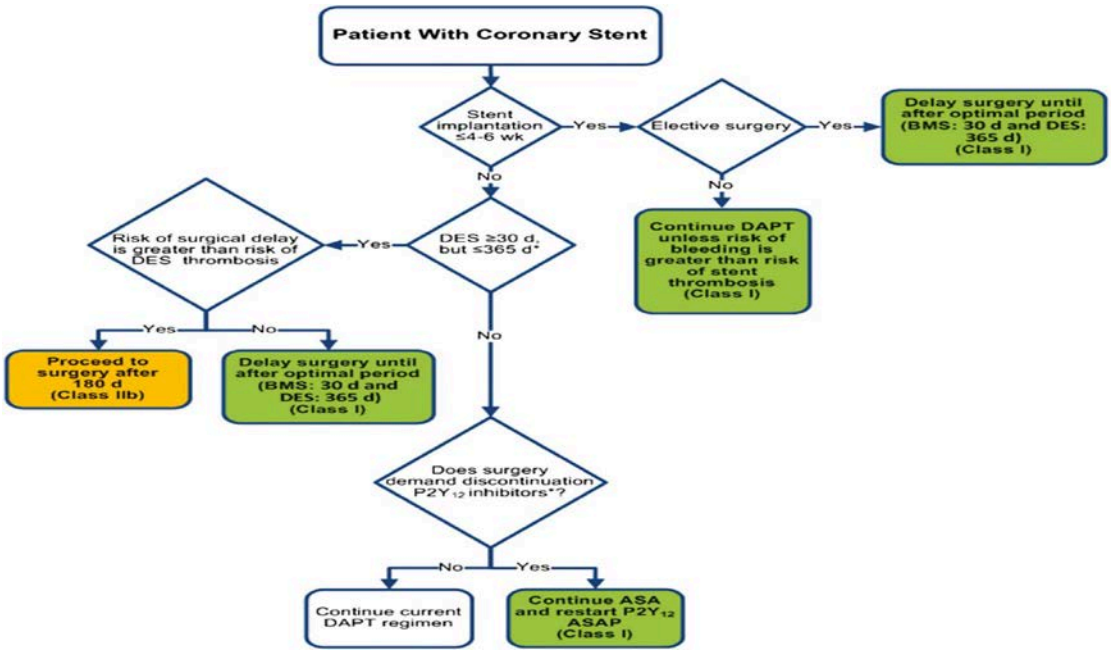

Figure9: Algorithm for Antiplatelet Management in Patients With PCI and Noncardiac Surgery

(Valgimigli ., 2014).

New antiplatelet agents:

Cangrelor is a new, rapidly acting, reversible ADP blocker currently undergoing phase III trials. It binds selectively and specifically to the $P2Y_{12}$receptor on the platelet surface. Unlike thienopyridines, the drug offers reversible antiplatelet activity with a rapid onset and offset of action, and does not need activation or conversion by the liver to an active metabolite. It is administered by i.v. infusion, with a plasma half life of 3–5 min, resulting in full recovery of platelet activity within 60 min. Such a drug would offer useful short term control of platelet function and may be more suitable as bridging therapy during the perioperative period ***(Amsterdam et al., 2014).***

Modified TEG:

Modified TEG (mTEG®) is a modification of the conventional TEG assay that uses reptilase (a proteolytic enzyme from snake venom) and Factor XIII to produce a cross-linked clot through which platelets can interact. Reptilase generates fibrin, reinforced by Factor XIII, creating a limited platelet interaction in the absence of thrombin generation. The resulting thromboelastogram produces an MA that is sensitive to the presence of thienopyridines and salicylates. Early results suggest good correlation with gold standard laboratory-based tests, such as optical platelet aggregometry. This novel assay could be very useful in monitoring the antiplatelet effects of cangrelor during bridging therapy, allowing its rate of infusion to be titrated against a pre-determined mTEG MA during the perioperative period ***(O'Gara et al., 2013).***

Perioperative management for patients with transplanted heart

With an increasing number of patients in the general population with a heart transplant, many of these patients are presenting with acute surgical pathologies which may require surgical intervention. These patients can pose a new challenge due to immunosuppression and altered cardiac physiology; therefore they require further preoperative assessment and optimization as well as intraoperative monitoring ***(Ramakrishna et al ., 2009).***

It is important to have a good understanding of the change in physiology of patients with a heart transplant. There are key factors which must be addressed including the pharmacological management of the denervated heart, change in haemodynamic status, and prevention of transplant rejection postoperatively ***(Batistaki et al ., 2013).***

The transplanted heart does not have sensory sympathetic and parasympathetic innervation; it therefore has a higher resting heart rate of 90–110 bpm secondary to the loss of vagal tone. The resting ECG is commonly altered showing two p waves: one is from the recipients' own sinoatrial node and the other is the donors' sinoatrial node. Patients are at higher risk of developing atrial flutter or atrial fibrillation. The patients' own SA node, although still functional, has no effect on the transplanted heart because the impulses cannot be conducted through the surgical suture lines. In the case of hypovolemia, a normal heart will increase its cardiac output by stimulating neurohormonal pathways resulting in increased heart rate and contractility; the transplanted heart cannot do this and is said to be “preload dependent” as cardiac output becomes

dependent on venous return .It has been shown that the transplanted heart may reinnervate over time ***(Swami et al ., 2011).***

It is crucial to ensure that the patient is fully optimized preoperatively. An echocardiogram should be performed prior to surgery, ensuring assessment of ventricular and valvular function, establishing the patients exercise tolerance by assessing stress test findings and if necessary obtaining a review by a cardiologist .It is important to assess patients for signs of organ rejection which include shortness of breath, fever, anuria, fatigue, fluid retention resulting in weight gain, and cardiac allograft vasculopathy, the risk of rejection is greatest in the first year after heart transplantation ***(Imamura et al ., 2015).***

Invasive monitoring is important to ensure tight control of blood pressure, getting accurate readings with an arterial line and hence avoiding hypotension, vasodilation, and acute decrease in preload. Strict aseptic technique during the insertion of both the arterial and central lines to prevent infection and risk of transplant rejection. Such monitoring is also important to monitor haemodynamic changes during laryngoscopy and tracheal intubation. In heart transplanted patients laryngoscopy and tracheal intubation may not produce a sympathetic response secondary to the loss of cardiac baroreceptor reflexes ***(Valerio et al ., 2014).***

In the transplanted heart, there is no alteration to heart rate in response to certain drugs including muscle relaxants (pancuronium and gallamine), anticholinergics (atropine and glycopyrrolate), and anticholinesterases (neostigmine and pyridostigmine).It is therefore important to consider other drugs that can be used in emergency situations, such as having ephedrine and isoprenaline ***(Miller et al ., 2010).***

It is important to ensure that immunosuppressant medications are continued to reduce the risk of organ rejection. Post transplant patients are started on immunosuppressive therapy to prevent organ rejection. The most common drug regimen includes tacrolimus, mycophenolate, and prednisone. It is important to understand the action of these drugs and the impact they may have on the delivery of anaesthesia ***(Blascoet al ., 2009).***

Tacrolimus acts by inhibiting T-lymphocyte activation as well as inhibiting IL-2 gene expression in T helper cells. It has multiple side effects which can have consequences for anaesthesia: hypertension, diabetes, neurotoxicity, and renal insufficiency. Prednisone has a similar side effect profile; however its action is different to tacrolimus because it has anti-inflammatory effect on organ systems. Mycophenolate mofetil is an inhibitor of inosine monophosphate dehydrogenase as well as having cytostatic effects on T- and B-lymphocytes. It also has implications for anaesthesia as it results in anaemia, leukopenia, and thrombocytopenia ***(Valerio et al ., 2014).***

So:

(i)To have an understanding that the transplanted heart has no sensory sympathetic and parasympathetic innervation makes them prone to developing atrial fibrillation and atrial flutter.

(ii)The transplanted heart is “preload dependent”; therefore it is important to maintain a sufficient systolic pressure and prevent hypovolemia.

(iii)The transplanted heart does not respond to muscle relaxants, anticholinergics, and anticholinesterases; therefore in emergency situations ephedrine and isoproterenol can be used.

(iv)To be aware of the side effect profile of immunosuppressive therapy and how this may affect the anaesthetic agents given is necessary.

(v)It is crucial to continue immunosuppressive therapy, considering other routes if necessary ***(Imamura et al ., 2015).***

Perioperative management of patients with cardiac implantable electronic devices

The HRS consensus statement emphasizes that best practice results from predetermination of appropriate perioperative management by the team who usually manages and monitors the cardiac implantable electronic devices(CIED). It is clear that availability of complete information about a patient's CIED and precise recommendations from the CIED team for the day of surgery can be very helpful ***(Salukhe et al ., 2004).***

It is desirable in general that a pacemaker has been checked within the last 12 months and an ICD within the last 6 months, but this cannot guarantee that nothing has changed in the interim. As discussed in the HRS consensus statement, the procedural/operative team should ideally be seeking the recommendations of the patient's CIED team in advance whenever feasible for elective procedures since all necessary information should reside with them. Failing this, the availability of an IEAP or a knowledgeable colleague with a programming device will be helpful to ensure device function. Unfortunately, these conditions are rarely met in real practice and certainly cannot be expected to be met off-hours and during urgent or emergent unscheduled cases***(Allen ., 2006).***

Thus, regardless of the circumstances (e.g. elective case without the recommendations of the CIED team or emergent case), the anaesthesiologist needs to be able to obtain certain key information and understand what can cause problems with a CIED if they are to take the specific recommended steps to avoid them, as outlined in the ASA Practice Advisory. A discussion of the perioperative considerations is followed by a delineation of specific actions to be taken ***(Allen ., 2006).***

Considerations:

Electromagnetic interference (EMI):

The most common issue arising in the perioperative period is interference with device function from EMI. Any apparatus that emits radiofrequency waves between 0 and 109 Hz can generate EMI and therefore interfere with proper device function. Table 3 provides a list of commonly encountered sources of EMI in the perioperative setting. Higher frequency waves (e.g. X-rays, γ-rays, infrared, and ultraviolet light) are unlikely to cause interference with CIED function, though repeated and/or prolonged exposure to certain types of radiation can cause deterioration of insulation within the device with resultant short-circuiting or other electrical problems ***(Stone et al ., 2009).***

Table 13

A list of factors associated with the generation of EMI commonly encountered in the perioperative setting. Reporting the anticipated presence of any/all such factors to the CIED team may help them devise appropriate recommendations

Electrocautery (monopolar>>>>bipolar)
Evoked potential monitors
Nerve stimulators (twitch monitors)
Fasciculations
Shivering
Large tidal volumes
External defibrillaton
Magnetic resonance imaging
Radio frequency ablation or lesioning
Extracorporeal shock wave lithotripsy
Electroconvulsive therapy

(Stone et al ., 2009).

For pacemakers in general, inhibition of pacing due to oversensing is the most common result of exposure to EMI, though in some cases, sudden asynchronous pacing, reversion to a programmed backup mode (often VVI or VOO mode), or both can be seen. Prolonged exposure to EMI can cause a pacemaker to initiate a noise reversion mode or noise suppression protocol which triggers asynchronous pacing until the noise stops ***(Ruiz et al ., 2009).***

With an ICD, EMI can result in inappropriate delivery of a defibrillatory shock. Thus, if pacing modes appear to be changing abruptly or intermittently on ECG monitors, unrecognized EMI should be considered. This being said, the potential for EMI to affect the behaviour of modern pacemakers has decreased significantly compared with prior generations of devices, with the nearly routine use of bipolar leads being a major factor ***(Apfelbaum et al ., 2011).***

The vast majority of devices now use bipolar leads; however, unipolar leads are still sometimes used when epicardial leads are placed (often in the pediatric population) and in adults with older devices. Bipolar leads minimize the physical distance over which the circuit is completed because both the anode and cathode are located very close to each other on the lead itself. In contrast, with unipolar leads, the lead tip acts as the cathode and the pulse generator acts as the anode to complete the circuit. There is a greater potential for interference from EMI with unipolar leads because in effect, the entire circuit acts as a large antenna. Additional reasons why modern devices are less susceptible to EMI noise protection algorithms, which disregard noise outside of the expected cardiac range of frequencies, and include the incorporation of filters and circuit shields that insulate the circuitry and internal components from the metal device casing ***(Crossley et al ., 2011).***

EMI–CIED interactions

There are several adverse outcomes potentially related to exposure of a CIED to EMI in the perioperative period that the anaesthesiologist should take steps to avoid. Table 4 defines the adverse outcomes to be avoided in patients with CIEDs, as any of these can result in significant morbidity or mortality due to hypotension, dysrhythmias, myocardial tissue damage, myocardial ischaemia, and/or potential secondary damage to other organ systems. In addition to potential harm to the patient, from the systems-based perspective, EMI exposure can cause delay or cancellation of scheduled surgery by necessitating additional surgical procedures to manage device malfunctions and can potentially extend hospital stays incurring increased medical costs ***(Zipes et al ., 2006).***

-Adverse outcomes to be avoided in patients with CIEDs:

- Damage to the device, the leads, or site of lead implantation.
- Failure to deliver pacing, defibrillation, or both.
- Changes in pacing behavior.
- Inappropriate delivery of a defibrillatory shock(if an ICD is present)
- Inadvertent electrical reset to backup pacing mode.

(Zipes et al . , 2006).

As outlined in the consensus statement, there are experience and data suggesting that the likelihood of adverse EMI–CIED interactions decreases with the distance from the EMI source to the pulse generator (a critical distance of 6 in. is mentioned). With modern subpectoral devices and electrosurgical cautery units, it is currently believed that the potential for interactions is markedly reduced when the surgery is below the umbilicus and the cautery dispersal pad is placed so as to direct the

current away from the pulse generator.28 Nevertheless, it remains the recommendation to take specific actions to minimize EMI exposure to the CIED and to protect the patient from the potential result of altered CIED behaviour as a result of exposure to EMI. Aside from the potential effects of EMI, one should also take care to avoid dislodging recently implanted leads (<6 weeks old; e.g. by placement of a pulmonary artery catheter). ***(Goldberger et al ., 2006).***

Decisions and actions

As outlined in the Practice Advisory, key principles in the perioperative management of the patient with a CIED are as follows.

Before operation:

Preoperative decision-making regarding the issues listed above is detailed in Figure 10.

- Determining that a CIED is present and defining the functionality of the device (e.g. pacemaker or ICD).
- Determining whether significant EMI will be present during the planned procedure that might affect the programmed behaviour of the CIED.
- Determining whether the patient is dependent on antibradycardia pacing and whether or not reprogramming of the pacemaker mode is required.
- If an ICD is present, deciding the manner in which the antitachycardia therapies shall be suspended (e.g. by a programming device or by temporarily applying a magnet to the device).
- Determining that the device is functioning as intended ***(Bardy et al ., 2005).***

Fig 10 Suggested algorithm for preoperative decision-making regarding a modern CIED with bipolar leads. Suggested actions involving magnet application assume that the magnet response for the device is enabled, and cautery dispersal pads are appropriately located. Additional considerations may involve suspending rate-adaptive functionality, increasing outputs for cases involving transfusions or large volume shifts, and increasing the backup rate of a demand pacemaker ***(Bardy et al ., 2005).***

Preoperative considerations

While there are no data conclusively demonstrating the need to perform a comprehensive preoperative evaluation of a CIED, there is a large anecdotal experience, as well as published case reports in which incomplete evaluation has resulted in intraoperative problems. In addition

to a thorough patient interview and relevant physical exam, the preoperative assessment should include a focused interview regarding the CIED and a review of all available medical records, ECGs, and chest X-rays. Occasionally, detailed information regarding the type of device, the indication for its implantation, and current settings will be in the patient's chart. However, this information is usually not available, and few patients (or their families) can verbally and accurately provide all of the necessary information, so it is up to the practitioner to use all available information to determine what is present, how it is programmed, if the patient is dependent on the device, if is it functioning as intended, and determine what needs to be done with it to prepare the patient for surgery ***(Allen., 2006).***

The chest radiograph (CXR) is particularly helpful to determine what is present. Examination of the CXR can immediately provide information about lead configuration, and thus whether the device is a single- or dual-chamber pacemaker, a biventricular device, or an ICD. Practitioners will be able to recognize the number and location of the leads (RA, RV, or both). Generally, the RV lead of an ICD has two thick radio-opaque sections representing the high-voltage coils for delivery of a defibrillatory shock and terminates in the RV. A biventricular system has three leads (one in the RA, one that enters the coronary sinus and travels towards the left side of the heart, and one in the RV that often has the radio-opaque coils indicating the presence of an ICD). Careful examination of the CXR can also help determine whether the device will function as intended. For example, one can usually identify a fractured lead (e.g. from subclavian ‘crush’) ***(Fiek et al ., 2004).***

Additional steps one can take to obtain necessary information include a review of the information card patients with implanted devices

are supposed to keep on hand (though this is rarely available in the preoperative holding area) and attempted phone calls to the patient's cardiologist or pacemaker clinic. If one can identify the device manufacturer (either by asking the patient or by markings on the device visible on CXR), then one can also attempt to get the requisite information directly from the manufacturer by calling their toll-free number ***(Abraham et al ., 2002).***

Next, it is essential to determine the dependence on the pacing function of the CIED. If a knowledgeable consultant with a programmer is involved, they will be able to recognize pacemaker dependency if there is a lack of spontaneous ventricular activity when the pacemaker is programmed to the VVI mode at a low rate. If no consultant is available, one should obtain a specific history and examine the ECG. A history that the indication for device implantation involved symptomatic bradyarrhythmia or syncope suggests pacemaker dependence, as does a history of AV nodal ablation. One should examine the ECG for P-waves and pacing spikes. If every P-wave and/or QRS complex on the ECG is preceded by a pacemaker spike, the likelihood is high that the patient is pacemaker-dependent and dependency should be the ***assumption (Bernstein et al ., 2002).***

Provocative manoeuvres to elicit bradycardia (e.g. prolonged Valsalva manoeuvre, or giving a small dose of edrophonium, esmolol, or adenosine) can be helpful to ensure effective sensing, pacing, and mechanical capture, but are not recommended and certainly should only be performed with extreme caution after assuring that a backup plan for pacing is already in place. Again, dependency should be the assumption if there is doubt, and there will rarely be the need for provocative manoeuvres ***(Fiek et al ., 2004).***

Once pacemaker dependency has been established, one needs to determine whether reprogramming is necessary. Formal reprogramming of a pacemaker to an asynchronous mode is only done for pacemaker-dependent patients who will be exposed to significant EMI. In prior years, it was considered preferable by many to have all pacemaker reprogramming done by a knowledgeable consultant using the manufacturer's programmer. However, experience has shown that a magnet can easily be placed and secured over the device to reliably and conveniently create an asynchronous pacing mode when needed with modern devices implanted since 2000 ***(Goldberger et al ., 2006).***

Furthermore, it is now appreciated that the use of a magnet might represent a safer and more convenient strategy due to the rapid reversion of the pacemaker to previous settings when the magnet is removed. Patients who are not pacemaker-dependent do not require reprogramming. If no reprogramming is deemed necessary, it is recommended that rate modulation be suspended in the perioperative period (it should be understood that rate adaptative functionality is suspended when a pacemaker is programmed to an asynchronous mode) ***(Zipes et al ., 2006).***

Despite recent data regarding the minimal EMI exposure to CIEDs distant from the site of surgery, in the interest of the highest level of safety for patients, without exception, the antitachyarrhythmia functions of an ICD should be suspended. This can be performed by reprogramming the device, although it is common nowadays to use a magnet for this purpose. While there are some caveats to this (discussed in detail below), the proper use of a magnet is a reliable and safe way to disable a modern ICD and can quickly restore the defibrillatory function

of the device (should it be required perioperatively) without the need for additional reprogramming ***(Stone et al ., 2009).***

Equally important as having the pacemaker reprogrammed where needed and/or having the ICD deactivated is assuring that appropriate monitoring and vigilance are maintained, with the immediate availability of temporary pacing or external defibrillation if necessary until all CIED settings have been restored. The usual convention is to monitor the patient with external defibrillation/pacing pads connected to a bedside monitor/defibrillator on standby. An anterior–posterior configuration of the pads is recommended because it is perpendicular to the usual axis of the leads, and theoretically minimizes the induction of current down the leads if the pads need to be used ***(Goldberger et al ., 2006).***

Magnet use

Pacemakers

Application of a magnet to a modern pacemaker produces an asynchronous mode of pacing to protect a patient from the effects of EMI. The asynchronous rate obtained depends on the programming of the device, the remaining battery life, and defaults that vary by manufacturer. The specific mode of asynchronous pacing (e.g. AOO, VOO, and DOO) depends on the programming configuration of the device. Once the magnet is applied, asynchronous pacing persists for as long as the magnet remains in place over the pulse generator. Removal of the magnet results in reversion to baseline device programming ***(Crossley et al .,2011).***

Implantable cardioverter defibrillators

While there are no specific recommendations, a magnet can be secured over the pulse generator of an ICD to suspend the arrhythmia

detection function of the ICD and prevent discharge. Subsequent removal of the magnet promptly reactivates the ICD. Compared with formal deactivation of detection by reprogramming, magnet use allows rapid re-initiation of the arrhythmia detection function of the device without the need for a programmer should a tachyarrhythmia occur and at the end of the procedure. The main caveat to the routine use of magnets to temporarily deactivate an ICD revolves around whether or not there is a possibility that the magnet response of the ICD is programmed to ignore magnet application ***(Apfelbaum et al ., 2011).***

Medtronic devices do not have such an option, and magnet application should reliably deactivate the device. Removal of the magnet should reliably reactivate the device. Some Boston Scientific and St Jude devices do have the option of programming the magnet response to off, which underscores the need to know how an implanted device is programmed (and illustrates why a false sense of security can result from the prevailing attitude of 'just stick a magnet on it'). If the patient has a Boston Scientific/Guidant Contak Renewal (a specific model of ICD that was subject to recall), a consultant should formally deactivate the device with a programmer ***(Apfelbaum et al ., 2011).***

Unlike Medtronic, St Jude, and devices from other manufacturers, Boston Scientific ICDs produce audible R-wave synchronous tones to let one know that the device has been successfully deactivated. As long as one hears these tones, arrhythmia detection is suspended. Removal of the magnet reactivates detection and the tones will cease. If the position of the magnet shifts from the device (e.g. during positioning), the tones will cease, indicating reactivation of the device. The annunciation of a continuous tone indicates that the Boston Scientific device is programmed to off, and should prompt consultation with a

knowledgeable colleague to interrogate the device. Failure to hear tones at all with magnet application suggests either that the magnet is not properly positioned, that the device is programmed to ignore magnet application, or that the device is not manufactured by Boston Scientific ***(Stone et al ., 2009).***

Medtronic devices also produce audible tones (similar to a European police siren) upon magnet application that indicate an alert is present, but which do not specifically indicate the status of antitachyarrhythmia detection or therapies. St Jude devices do not annunciate tones upon magnet application. One should always remember that all ICDs have backup pacing function ***(Crossley et al ., 2011).***

Even when the ICD has been deactivated by a magnet, pacemaker function of an ICD is not affected. Thus, in a patient with an ICD, the magnet response will always be to deactivate the ICD and the pacing behaviour will not change to an asynchronous mode. If it is determined that an asynchronous mode is required for a pacemaker-dependent patient, this reprogramming should be performed by a knowledgeable consultant with a device programmer, or placement of a temporary transvenous pacemaker should be considered. If an asynchronous mode of pacing is manifest following application of a magnet, it is highly unlikely that an ICD is present ***(Crossley et al ., 2011).***

Anaesthetic drugs and technique

Commonly used anesthetic agents are not believed to affect pacing thresholds, though the sequelae of anaesthetic management can, including hyperventilation (which can abruptly lower serum potassium concentration), significant acid–base, electrolyte, or both disturbances, significant volume loads, transfusion of blood, myocardial ischaemia, and

high blood concentrations of local anaesthetics that can increase capture thresholds of the leads and alter lead impedance ***(Stone et al ., 2009).***

Conclusion

The ideal perioperative management of patients with a CIED derives from a multidisciplinary approach involving the procedural team, the patient's CIED team, and possibly IEAPs. Where such an approach is not feasible or has not occurred as envisioned, safe and effective perioperative care must still be rendered, and it is incumbent on anaesthesiologists to become familiar with the current recommendations and their implementation. While advances in modern CIED technology and in surgical equipment have decreased vulnerability to EMI in recent years, in the interest of the highest possible level of patient safety, the current practice recommendations continue to emphasize the need for an individualized and thoughtful approach to each patient, with specific actions taken to minimize CIED exposure to EMI and to protect patients from untoward haemodynamic effects as a result of such exposure in the perioperative period. The need to have every CIED interrogated before discharge of a patient from a monitored setting remains a controversial issue, but the recommendations set forth in the HRS consensus statement provide guidance in this decision-making process ***(Crossley et al ., 2011).***

Summary

The human heart consists of four chambers: The left side and the right side each have one atrium and one ventricle. Each of the upper chambers, the right atrium (plural = atria) and the left atrium, acts as a receiving chamber and contracts to push blood into the lower chambers, the right ventricle and the left ventricle. The ventricles serve as the primary pumping chambers of the heart, propelling blood to the lungs or to the rest of the body .

There are two distinct but linked circuits in the human circulation called the pulmonary and systemic circuits. Although both circuits transport blood and everything it carries, we can initially view the circuits from the point of view of gases. The pulmonary circuit transports blood to and from the lungs, where it picks up oxygen and delivers carbon dioxide for exhalation. The systemic circuit transports oxygenated blood to virtually all of the tissues of the body and returns relatively deoxygenated blood and carbon dioxide to the heart to be sent back to the pulmonary circulation.

The autorhythmicity inherent in cardiac cells keeps the heart beating at a regular pace; however, the heart is regulated by and responds to outside influences as well. Neural and endocrine controls are vital to the regulation of cardiac function. In addition, the heart is sensitive to several environmental factors, including electrolytes.

All patients scheduled to undergo noncardiac surgery should have an assessment of the risk of a cardiovascular perioperative cardiac event. The patient functional status is an important determinant of risk.

Identification of risk factors is derived from the history and physical examination; the type of proposed surgery influences the risk of perioperative cardiac event.

We use either the revised cardiac risk index (RCRI), also referred to as the Lee index, or the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) risk prediction rule to establish the patient's risk.

The ACC/AHA guidelines has relied on functional capacity, clinical characteristics of the patient, prescence of active cardiac condition and the extent of the surgical procedure. After preoperative evaluation, the physician should determine the clinical predictors as major, intermediate, or minor.

We obtain an electrocardiogram (ECG) in patients with cardiac disease (except in those undergoing low-risk surgery) in large part to have a baseline available should a postoperative test be abnormal.

For patients with known or suspected heart disease (ie, cardiovascular disease, significant valvular heart disease, symptomatic arrhythmias), we only perform further cardiac evaluation (echocardiography, stress testing, or 24-hour ambulatory monitoring) if it is indicated in the absence of proposed surgery.

For the most part, chronic cardiovascular medications, such as aspirin, ACE inhibitors, ARBs, and β-blockers, should be continued, but the decision should be individualized to each patient's circumstances. Ideally, $P2Y_{12}$ inhibitors should be held before surgery, aside from cases of recent coronary stenting, where expert opinion should be sought. Finally, there are no compelling data indicating that starting new

cardiovascular medications before surgery can decrease perioperative risk, although there may be a role for perioperative β-blockade in specific circumstances.

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الملخص العربي

المقدمة

من المهم تقييم مرضي القلب وذلك لأنا نواجههم في العمليات كثيراً لذلك نحن بحاجة إلى إجراء تقييم الوضع الطبي الحالي المريض و تقديم توصيات بشأن خطر التعرض لمشاكل في القلب خلال الفترة المحيطة بالجراحة بأكملها وذلك ليستطيع طبيب التخدير، والجراح إستخدامها في صنع قرارات العلاج التي قد تؤثر على القلب على المدى القصير والطويل. الهدف من التقييم هو التعرف على إستراتيجيات الإختبار والعلاج الأكثر ملائمة لتحسين رعاية المريض، وتجنب إختبارات لا لزوم لها .

وأمراض القلب التي ينبغي ان يركز عليها التقييم هى : مرض الشريان التاجي (إحتشاء عضلة القلب والذبحة الصدريه)، فشل القلب، ارتفاع ضغط الدم، أمراض الصمامات، وعدم إنتظام ضربات القلب.

بالإضافة إلى تحديد وجود أمراض القلب الموجودة من قبل، فمن الضروري تحديد شدة المرض، والمعالجة المسبقة. وهناك عوامل تساعد على تحديد المخاطر القلبية مثل القدرات الوظيفية والعمر والظروف المرضية (مثل داء السكري، وأمراض الأوعية الدموية الطرفية، الفشل الكلوي، ومرض الإنسداد الرئوي المزمن)، ونوع الجراحة (إجراءات الأوعية الدموية الطويله و إجراءات الرأس والعنق تعتبر الأعلي خطرا).

وفي عام ١٩٧٧ وضع غولدمان أول مؤشرات الخطر لأمراض القلب، والتي تضمنت تسعة متغيرات مرتبطة بزيادة خطر حدوث مضاعفات القلب المحيطة بالجراحة وهذا أصبح يعرف بإسم مؤشر جولدمان .

وفي عام ١٩٩٩، نشر لي مؤشر خطر القلب وقد حدد ستة متغيرات مستقلة.

وفي عام ٢٠٠٧ اسست رابطة القلب الأميركية والكلية الأميركية لأمراض القلب مؤشرات للخطروفى عام ٢٠١٤ قد صرحت بإنشاء اثنين من أحدث الادوات والتي جمعها مستقبلي بيانات عن العمليات التي تجرى في المستشفيات في الولايات المتحدة وقد إستخدمت البيانات لإنشاء حاسبات الخطر.

مع الأخذ بعين الاعتبار الخطر على القلب المحيط بالجراحة وفقا للقدرة الوظيفية، يجب على طبيب التخدير أن يقرر ما إذا كان يحتاج إلى مزيد من التقييم أو لعلاج قبل العمليه للمرضى الذين من الصعب تحديد القدرة الوظيفية لهم نظراً لخضوعهم لعمليه بالأوعية التاجية سابقاً و الذين لديهم حالة القلب غير مستقره، أو الذين لديهم أمراض مصاحبة شديدة قد يحتاج إلى مزيد من التقييم. تتوفرالعديد من تقنيات التصويرللقلب ، بما في ذلك تصوير الأوعية التاجية، وضربات القلب بالإجهاد، و التصوير بالرنين المغناطيسي والتصوير المقطعي، والدراسات النووية لعضلة القلب .

احدث الطرق لتقييم مرضي القلب لاجراء العمليات الجراحية الغير قلبيه

رسالة

مقدم من

الطبيبة/ هبه حمدي احمد محمد

بكالوريوس الطب والجراحة

توطئه للحصول علي درجة الماجستير في التخدير والرعاية المركزة

تحت اشراف

أ.د /محمد يسري سري

استاذ التخدير والرعايه المركزة

بكلية الطب البشري جامعة بنها

د/محمد عادل عبد المنعم خشبه

مدرس التخدير والرعاية المركزة

بكلية الطب البشري جامعة بنها

كليـــة الطـــب

جامعة بنها

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