CHIRURGIE CARDIAQUE / CARDIAC SURGERY

SURGICAL ASPECTS OF RHEUMATIC HEART DISEASE: PART 3

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Abstract

Acute Rheumatic Fever (ARF) and Rheumatic Heart Disease (RHD) remain significant non-communicable diseases in developing countries and emerging economies. Part one of this five part series discussed general aspects of ARF and RHD. Part two focused on medical and interventional approaches and treatment. The present part three will focus on surgical aspects of RHD. This will highlight the history, indications, timing, and perioperative aspects of RHD. Emphasis will be placed on surgery in developing countries and emerging economies, where there are restrictions with relation to advanced technology, cost, access and availability of services, experience with repair techniques and care, as well as social and political constraints.

Key-words: Acute Rheumatic Fever - Rheumatic Heart Disease - Surgery

INTRODUCTION

Acute rheumatic fever (ARF) targets young patients ages (5-15 year olds), following Group A beta hemolytic streptococcus pharyngitis[1]. Onset of ARF occurs within 1-5 weeks after initial infection. Cardiac involvement occurs in 10-40% of patients after the first attack, and more after recurrent attacks. The overall global burden of RHD is estimated at a prevalence 15.6 to 19.6 million, an annual incidence of 471,000, with an occurrence of 10-374 cases /100,000 population, and an annual global mortality of 233,000 [1,2,3]. In addition, the majority or 80% of the global burden of RHD patients live in low and middle income countries (LMIC's).

Surgery for RHD sequelae presents a challenge, especially in developing countries and emerging economies where the incidence is very high. Patients present late due to delayed presentation or delayed referral. In addition, access, availability, and ability for surgical care is limited secondary to distance, financial constraints, political issues, medical and non-medical human resources, and issues related to infrastructure, and operative equipment, drugs, and disposables. This review will highlight the perioperative aspects of the sequelae of RHD, with emphasis on the mitral valve, and the multivalve patient groups. Specific surgical techniques and postoperative acute and chronic complications will be covered in parts 4 and 5.

History of heart valve surgery

The history of closed cardiac surgery began in 1896 with Rehn's closure of a penetrating stab wound to the heart [4-7]. In 1893, Daniel Hale Williams (1856-1931) performed open heart surgery on a young man with severe stab wounds to his chest (8). With a limited array of surgical equipment and medicine, he opened the man's chest cavity and operated on his heart. The patient recovered within 51 days and went on to live for 50 more years.

Cardiac valve surgery emerged with as a concept when Brunton first suggested opening a stenotic rheumatic mitral valve in 1902[5]. Aside from subsequent animal research on this concept, it was not until 1923 that Cutler performed the first successful closed mitral valvotomy using a valvulotome placed via an apical trans left ventricular approach (LV)[3, 5]. Souttar performed a subsequent finger fracture closed commissurotomy in 1925 via a trans atrial approach[5]. The accelerated period of evolution occurred in 1948 when both Harken and Bailey independently performed a conventional closed mitral commissurotomy using the Souttar finger fracture approach[9-11]. In 1954, the treatment of mitral valve stenosis was advanced with the advent of the mechanical dilator, a relatively simple device that was designed and first used by Dubost[6]. The dilator had 2 parallel blades that could be passed through the left atrium and into the valve. Subsequently, the Tubbs dilator was modified based on a concept first employed by Logan who dilated an aortic stenotic valve. Tubbs observed the procedure where both the aortic and mitral valves were dilated via the LV approach. Tubbs then modified the dilater to expand to a larger size (3.5cm) to accommodate the larger mitral valve[12, 13].

With the advent of open heart surgery in 1953, open mitral commissurotomy, employing cardiopulmonary bypass (CPB), was reported in 1957 and became widely employed in the early 60's [14-16].

For aortic valve disease, Hufnagel and Harvey, in 1952, introduced a silicone-type ball (methacrylate) valve in a patient's descending aorta to treat aortic regurgitation This valve partially relieved aortic regurgitation by reducing the left ventricular load by about one-third to one-half [6,17,18].

Fresh aortic tissue valves, both autologous and heterotologous, were introduced in the early 60's by Ross and Barratt-Boyes. These valves were mainly implanted in the aortic annulus position. Even before valve prostheses became available, Ross conceived the idea of implanting a patient's own pulmonary valve as an autograft into the aortic annulus, and replacing the pulmonary valve with a homograft[6]. Other tissue sources, including fascia lata and dura mater, were introduced in the mid 70's[19, 20]. O'Brien et al. (21), in 1987, from Australia, introduced the autologous aortic and pulmonary valve/root cryopreservation techniques which remain in use today.

Braunwald et al., in 1960[22], performed the first non-commercial mitral valve replacement utilizing a flexible polyurethane foam prosthesis. The next major advance was a commercial mechanical valve replacement, which was performed almost simultaneously by Harken, who used a double-caged ball-and-seat aortic prosthesis, and Starr, who used a caged ball-and-seat mitral valve prosthesis. Both models incorporated a silastic ball within a metal cage [23, 24, 25]. The subsequent development of commercially available mechanical and bioprosthetic valves in the 1960's and 70's continues to evolve up through the present [6, 26, 27].

Carpentier's innovative and pioneering work with mitral valve repair in the early 1970's ushered in a wave of enthusiasm for less traumatic approaches to mitral valve diseases [28]. Mitral valve repair permitted a more anatomical approach with preservation of the subvalvular apparatus, as well as eliminating the need for chronic anticoagulation. However, the development of aortic valve repair for rheumatic disease has not been widely utilized, whereas repair for tricuspid insufficiency has evolved with good success, especially for functional involvement without organic rheumatic disease[28, 29].

At present over 90,000 commercial heart valves are implanted in the USA yearly, with 280,000 implanted yearly worldwide [26].

Historically, a number of prosthetic valves have been designed and produced (table 1) [26]. The Society of Thoracic Surgeons (STS) publishes a yearly update of the current availability of commercial devices[33]. Presently, there are a variety of approved mechanical and bioprosthetic valves, valved conduits, as well as valve rings and bands (figures 1, 2).

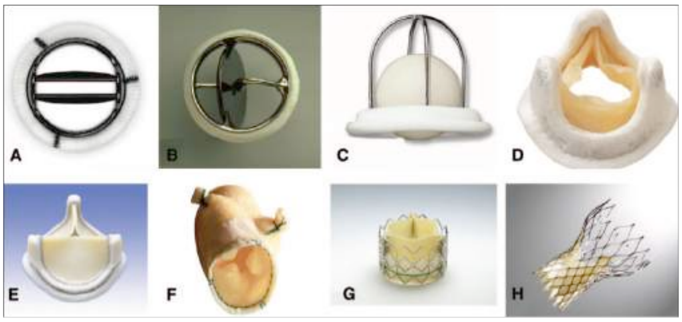

Figure 1. Variety of heart valves: Valve rings and Figure 2.Valve rings and bands.https://upload.wikimedia.org/wikipedia/en/thumb/2/21/Anuloplasty _Rings.jpg/220px-Ann uloplasty_Rings.jpg

Figure2: https://grosspathology-sites.uchicago.edu/sites/grosspathology.uchicago.edu/files/styles/columnwidtwider/public/uploads/images/Heart-Valves.jpg?itok=W-EVl_z1

Current mechanical valves include tilting, non-tilting , and bileaflet valves. The latter is the most common type presently used. Third generation bioprosthetic valves (are primarily porcine, or bovine pericardial with zero or low pressure fixation with glutaraldehyde, as well as antimineralization treatment [29]. They are either available as stented or non-stented. At present there is a controversial consensus with regards to the optimal choice of these devices, especially in low/middle income countries (LMIC's) with selection of mechanical vs. bioprosthetic valves (figure 3, 4) (table 2a,b) [29-32].

Figure 3

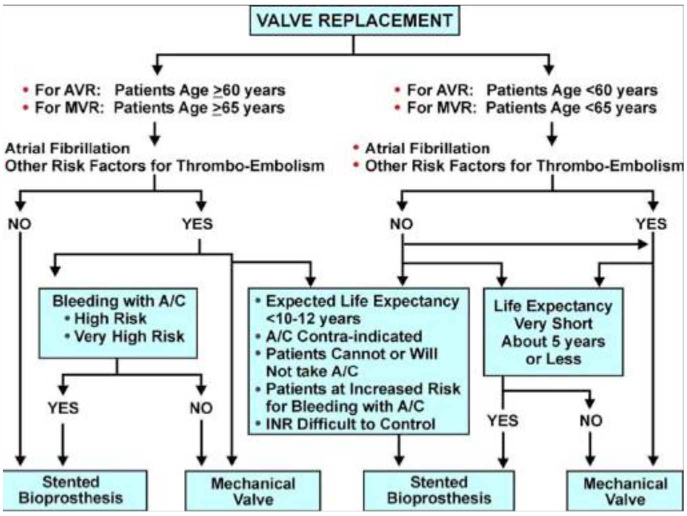

Figure 4

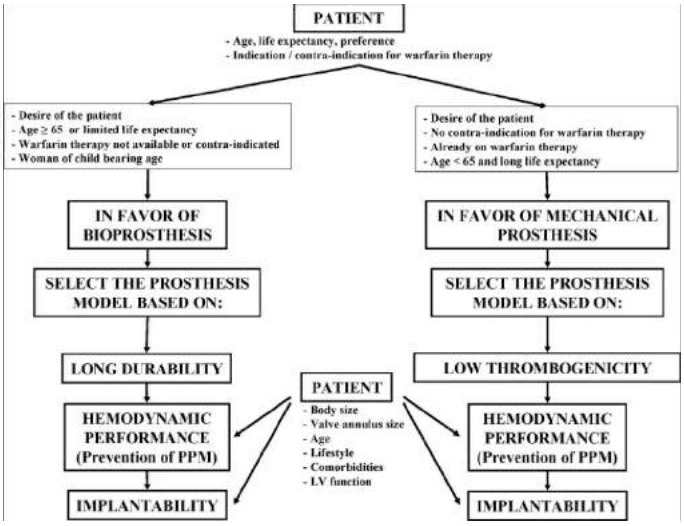

Table 2a,b

Choice of the aortic/mitral prosthesis : in favour of a bioprosthesis

	Class	Level
A bioprosthesis is recommended according to the desire of the informed patient.	I	C
A bioprosthesis is recommended when good quality anticoagulation is unlikely (compliance problems, not readily available) or contraindicated because of high bleeding risk (prior major bleed, comorbidities, unwillingness, compliance problems, lifestyle, occupation).	I	C
A bioprosthesis is recommended for reoperation for mechanical valve thrombosis despite good long-term anticoagulant control.	I	C
A bioprosthesis should be considered in patients for whom future redo valve surgery would be at low risk.	IIa	C
A bioprosthesis should be considered in young women contemplating pregnancy.	IIa	C
A bioprosthesis should be considered in patients aged > 65 years for prosthesis in aortic position or > 70 years in mitral position, or those with life expectancy lower than the presumed durability of the bioprosthesis.	IIa	C

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Choice of the aortic/mitral prosthesis : in favour of a mechanical prosthesis

	Class	Level
A mechanical prosthesis is recommended according to the desire of the informed patient and if there are no contraindications for long-term anticoagulation.	I	C
A mechanical prosthesis is recommended in patients at risk of accelerated structural valve deterioration.	I	C
A mechanical prosthesis is recommended in patients already on anticoagulation because of a mechanical prosthesis in another valve position.	I	C
A mechanical prosthesis should be considered in patients aged < 60 years for prosthesis in the aortic position and < 65 years for prosthesis in the mitral position.	IIa	C
A mechanical prosthesis should be considered in patients with a reasonable life expectancy, for whom future redo valve surgery would be at high risk.	IIa	C
A mechanical prosthesis may be considered in patients already on long-term anticoagulation due to high risk for thromboembolism.	IIb	C

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Risk factors

Cardiac surgical risk stratification models are important in the decision making process for cardiac valve surgery[34-41]. Models to determine outcomes are derived from univariate or multivariable regression analysis.Yet, despite the objective risk stratification scores, based on large database systems, each patient must ultimately be individualized, based on experience, clinical judgment and the patient's particular situation. The major risk factors for valve surgery focus on the patient's clinical status. This includes acute presentation and emergency or urgent surgery, age, reoperation, and presence of coronary artery disease. Reduced ejection fraction (EF), and severity of the valve lesion(s) are less important, though relevant. Furthermore, not all the variables that may impact on outcome are presented. Examples include calcified ascending aorta, severe mitral annular calcification, or pulmonary hypertension[30]. In addition, referral patterns vary, and are controlled by the physicians, where late referral and advanced disease is a major risk factor, not to mention late presentation.

At least 12 risk algorithms have been developed for aortic stenosis alone[35]. Lee et al, in 2011,[36] reported the STS 15 year outcome trends in North America. Risk profiles worsened over time. This is in contrast to the Fu Wai Hospital experience in Beijing, China where >25% of valve operations were multiple valve procedures compared to 11% in North America[37]. Also noted in China is that >50% of multiple valve procedures were performed for RHD.

Specific variables regarding RHD are important. Albeyoglu et al.38 reviewed 386 patients undergoing rheumatic mitral valve replacement with an operative mortality of 4.3%, and 12.8% for patients undergoing redo MVR. Acute presentation, age >70, left atrial diameter >60 mm, prolonged CPB, and postoperative low output state were significant risk factors in the redo group. In the LMIC's, late presentation with multiple valve disease, decreased LV function, infectious endocarditis, concomitant coronary artery revascularization, and associated comorbidity, especially pulmonary hypertension, and renal dysfunction, contributed to the morbid risk factors. The STS and EACTS risk scores are the most common scores utilized, and are readily available on the internet[39, 40].

It is important to achieve a consensus on the definitions of morbidity and mortality following cardiac valve surgery. Standardized guidelines have been developed by an Ad Hoc committee of the American Association for Thoracic Surgery (AATS), the Society of Thoracic Surgery (STS), and the European Association for Cardiothoracic Surgery (EACTS)[41, 42].

Early mortality is all-cause mortality at 30, 60, or 90 days, regardless of location (home, or health care facility). Valve morbidity includes structural or nonstructural valve prosthetic valve or ring dysfunction, valve thrombosis, embolism (cerebral or systemic), bleeding event, composite thrombosis, operative valve endocarditis, and re-intervention.

Blackstone[43] provided a comprehensive discussion on the risk factors of cardiac surgery with emphasis on introducing new processes and optimizing current patient care algorithms. This involves prospective research, innovation, and application of old or new knowledge. It is also difficult to quantify risk factors related to delayed presentation or referrals, as well as limitations related to available facilities, medical personnel, and support in risk assessment, especially in developing countries and emerging economies.

Indications

The indications for surgery have been well studied utilizing evidence based methodology (Class of recommendation [COR]; Level of evidence [LOE]) (table 3) [44- 45].

Table 3

Classes of recommendations COR)
Class I Evidence and/or general agreement that a given treatment or procedure is beneficial, useful, effective. Is recommended/is indicated
Class II Conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of the given treatment or procedure. **Class IIa** Weight of evidence/opinion is in favour of usefulness/efficacy. Should be considered **Class IIb** Usefulness/efficacy is less well established by evidence/opinion. May be considered
Class III Evidence or general agreement that the given treatment or procedure is not useful/effective, and in some cases may be harmful.Is not recommended
Levels of evidence (LOE)
Level of evidence A Data derived from multiple randomized clinical trials or meta-analyses.
Level of evidence B Data derived from a single randomized clinical trial or large non-randomized studies.
Level of evidence C Consensus of opinion of the experts and/ or small studies, retrospective studies, registries

Indications can be absolute or relative, as are contraindications. Surgery is performed for acute or chronic RHD. However, surgery for acute rheumatic carditis with a dilated LV and secondary severe mitral regurgitation is not common, occurring mostly in younger patients. In children and adolescents aggressive medical management is the preferred approach since symptoms of heart failure tend to improve or resolve with bed rest, rhythm control, diuretics, digoxin, aspirin and steroids. Surgery in the acute phase is associated with poor outcomes[46, 47].

Guidelines from the American Heart Association/ American College of Cardiology (AHA/ACC) and the European Society of Cardiology (ESC) for the management of chronic mitral and aortic valve diseases diseases are well established (figures 5, 6) (tables 4, 5) [44, 45],

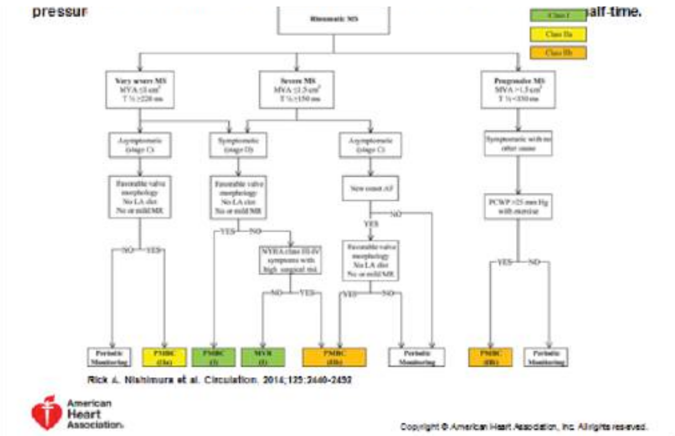


Figure 5: Indications for Intervention for Rheumatic MS.AF indicates atrial fibrillation; LA, Left atrial; MR, mitral regurgitation; MS, mitral stenosis; MVA, mitral valve area; MVR, mitral valve surgery (repair or replacement); NYHA, New York Heart Association; PCWP, pulmonary capilary wedge pressur half-time

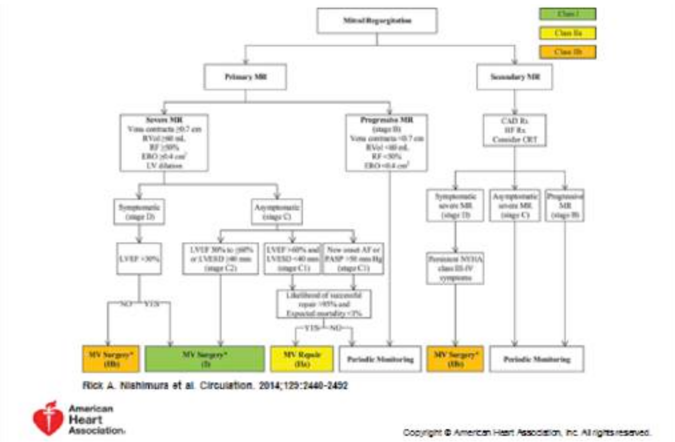
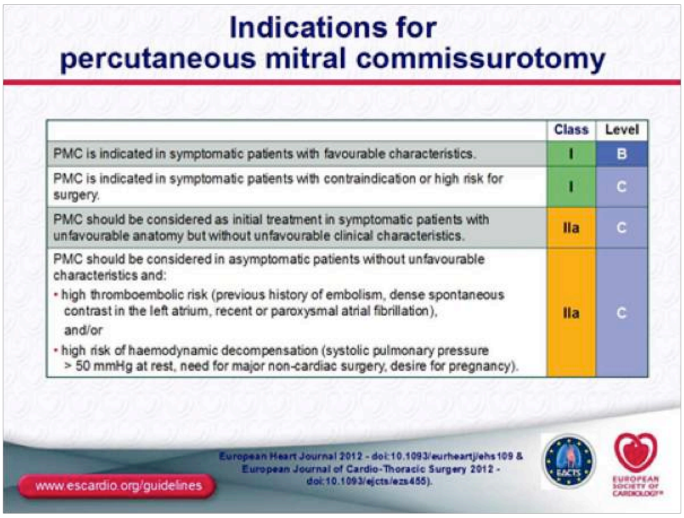


*Figure 6: Indications for Surgery for MR.*Mitral valve repair is preferred over MVR when possible*

Table 4



Indications for percutaneous mitral commissurotomy

	Class	Level
PMC is indicated in symptomatic patients with favourable characteristics.	I	B
PMC is indicated in symptomatic patients with contraindication or high risk for surgery.	I	C
PMC should be considered as initial treatment in symptomatic patients with unfavourable anatomy but without unfavourable clinical characteristics.	IIa	C
PMC should be considered in asymptomatic patients without unfavourable characteristics and: • high thromboembolic risk (previous history of embolism, dense spontaneous contrast in the left atrium, recent or paroxysmal atrial fibrillation), and/or • high risk of haemodynamic decompensation (systolic pulmonary pressure > 50 mmHg at rest, need for major non-cardiac surgery, desire for pregnancy).	IIa	C

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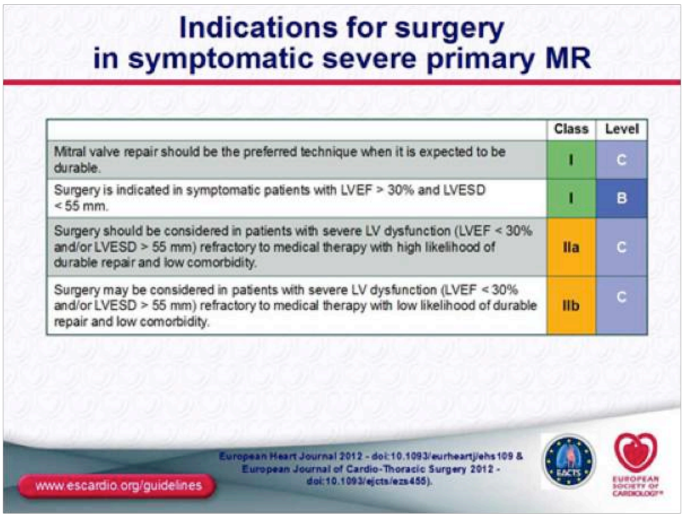
Table 5



Indications for surgery in symptomatic severe primary MR

	Class	Level
Mitral valve repair should be the preferred technique when it is expected to be durable.	I	C
Surgery is indicated in symptomatic patients with LVEF > 30% and LVESD < 55 mm.	I	B
Surgery should be considered in patients with severe LV dysfunction (LVEF < 30% and/or LVESD > 55 mm) refractory to medical therapy with high likelihood of durable repair and low comorbidity.	IIa	C
Surgery may be considered in patients with severe LV dysfunction (LVEF < 30% and/or LVESD > 55 mm) refractory to medical therapy with low likelihood of durable repair and low comorbidity.	IIb	C

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whereas the general indications or treatment strategies for the other major pathologies are also noted (figures 7-9) [44, 45].

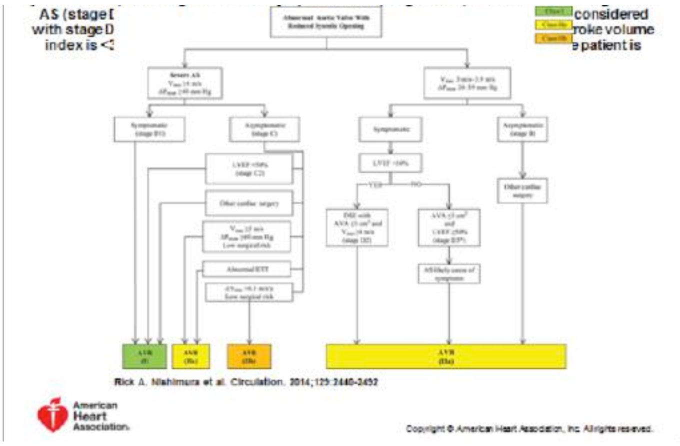
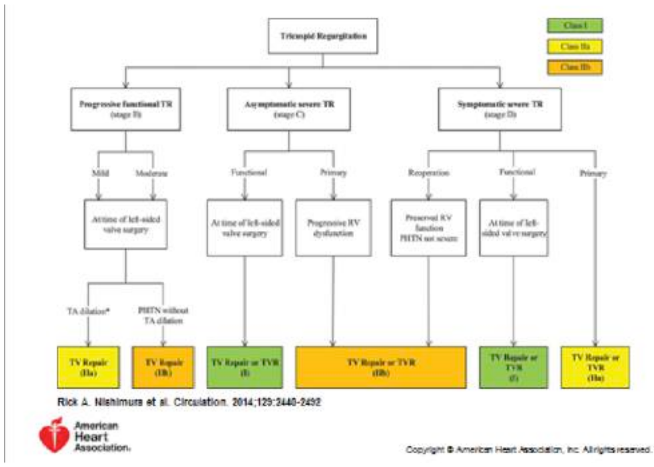


Figure 7: Indications for AVR in Patients Whith AS. Arrows show the decision pathways that result in a recommendation for AVR. Periodic monitoringis indicated for all patients in whorn. AVR is not yet indicated, including those with asymptomatic AS (stage D or C) and those with low-gradient AS (stage) considered with stage Droke volume index is the patient is

Figure 9: Indications for Surgery. *See table for definition of stages



Indications for surgery can be absolute or relative, as are contraindications. Patients postponed or denied surgery are difficult to document, insofar as the reasons are hard to elucidate in the literature. Risk factors include age, comorbidity, socioeconomic issues, and anatomic technical reasons. The major factors involved in the assessment or evaluation for surgery include symptomatic versus asymptomatic status (NYHA class I-IV), degree and extent of valve pathology, ventricular dysfunction, and associated sequelae i.e. atrial fibrillation, pulmonary hypertension, and comorbidity, especially nutritional status. Surgical results are directly related to these factors, as well as perioperative factors that include mortality, and early and late complications, especially endocarditis, bleeding, thromboembolism, and anticoagulation regulation.

Timing of Operation

Acute or emergency operations are performed within the first 24 hours of diagnosis, urgent operations occur during the same hospitalization, and elective future operations are scheduled following hospital discharge. Other categories include delayed operation usually for optimizing comorbid factors, or reevaluation pending more information, second opinions, changes in clinical status, or additional consultations. Rejected, denied, or postponed operations are difficult to categorize. High risk cases are frequently denied surgery in developing countries, given the high morbidity and mortality, as well as costs. Delayed presentation is very common, secondary to poor access, patient reluctance, or delayed referral for a variety of reasons by the treating doctors.

As noted, serious deliberation regarding appropriate need and timing of surgery is required for acute rheumatic carditis since aggressive medical treatment, including steroids, can ameliorate hemodynamic mitral regurgitation. A cautious delay may even avoid operation entirely, especially with resolution of MR secondary to improved LV function in the acute pediatric carditis group[46]. However, Carpentier and others have observed a decrease in the inflammatory syndrome in several patients following repair of severe MR during the acute phase[47].

Nishimura and Schaff[48] stress the importance of matching symptoms with underlying pathophysiology. Severe MR may occur in both symptomatic and asymptomatic patients. Thus it is prudent to offer surgery to the asymptomatic patients, given the development of symptoms in the latter group may have reached irreversible levels and render the patient non operative or higher risk with a poor prognosis.The improved results and lower risk of mitral valve repair supports this recommendation.

Perioperative aspects[49- 52]

Preoperative phase

The perioperative sequence for valve surgery includes preoperative preparation, anesthesia, perfusion, operation, postoperative care, early/late follow-up, and subsequent continued surveillance.

An accurate diagnosis and treatment plan is essential for a successful outcome. A 2D transthoracic echocardiogram (TTE) is sufficient for RHD diagnosis. Cardiac catheterization or angiography is required when there is multivalve involvement, associated coronary artery disease, discrepancy between the clinical and TTE findings, or low gradients with decreased LV function. Magnetic resonance imaging (MRI) or computed tomography are rarely needed.

Preoperative dental evaluation, ear examination for chronic otitis media, past and current medications, nutritional status, anticoagulation management, and evaluation of laboratory and diagnostic studies are routinely performed. Previous operative reports (anesthesia, operation, and perfusion records), when available, should be obtained and reviewed. The evaluation should include nutritional status, cardiac cachexia, history of dizziness, stroke, shortness of breath, dyspnea on exertion, evidence of endocarditis, heart failure (NYHA- ACC/AHA classification), anticoagulation issues, pulmonary hypertension, atrial fibrillation, and pregnancy concerns. Comorbidity, especially diabetes, needs to be evaluated and controlled. Availability of blood and blood products, especially fresh frozen plasma (FFP) and platelets, are confirmed. In tropical areas and developing countries worm infestation, ear infections, malaria, sickle cell trait or disease, HIV/AIDS, TB, and hepatitis B remain significant comorbid problems, and warrant aggressive screening and evaluation. Patient and family socioeconomic status, appropriate counseling regarding risk, complications, death, and follow-up need to be addressed[49-52]. Awareness of the home care environment, and the availability of postoperative follow-up is crucial, especially where anticoagulation treatment and monitoring is concerned. Preoperative diagnostic testing is summarized in table 6.

Table 6. Preoperative evaluation for valve surgery

Clinical status: previous clinical hospital records, out-patient reports and studies, operative reports, if any, allergies (especially antibiotics, protamine, heparin), acute, chronic, emergency, urgent, elective, AF, heart failure, pulmonary hypertension, pulmonary edema, cachexia, dental, comorbidity, current medications. Height, weight, body service area (BSA). Oral dental clearance
Laboratory: CBC, chemistry, renal function, sedimentation rate, C Reactive Protein, coagulation profile, drug levels, Sickle cell, malaria testing. HgB A1C diabetes Type and cross 2-4 units of blood. Ensure blood is available and ready . Check for cold agglutinins .
Diagnostic: Review of CXR, ECG, ECHO, CT scan, MRI, Cardiac cath, and Angiography. Chest x-ray (PA and lateral in redo operations) to evaluate lung fields, pleural effusions, and calcified aorta (especially important in a redo to note the number of sternal wires). CT scan of chest is helpful if calcified aorta is suspected on chest x-ray. Carotid Doppler scan only for patients over the age of 50, or with bruits, previous TIA's or CVA.
Social history: economic issues, medical follow-up care, availability of drugs.

Aspirin should be discontinued [5-7] days prior to surgery, and clopedegril (Plavix) 10 days prior. Warfarin (Coumadin) can be stopped or substituted with IV heparin 24-48 prior to operation. Beta blockers are continued. Prophylactic antibiotic administration is important. Engelman et al.[53] reports the STS guidelines for antibiotic use. The common regimen includes cefazolin 1-2gms. IV in adults at least 30-60 minutes prior to surgical incision (Vancomysin if MRSA, MRSE; add aminoglycoside if allergic to cephalosporins). Postoperative regimen includes 3 more doses (1 gram every 8 hours over 24 hours. Dental clearance is often overlooked, especially in programs without access to dental or oral surgery resources [54].

Procedure selection

A variety of operative valve techniques are available, with attendant advantages and disadvantages. Indications for interventional procedures were reviewed in part 2 for mitral stenosis and outlined by AHA/ACC guidelines (figure 5) (44). Further discussion regarding valve repair, valve replacement, and perioperative complications will be discussed in parts 4, and 5. The proposed operation, whether it is repair or replacement with mechanical or bioprosthetic valves, should be reviewed with the patient, family, and referring doctors. The risks, benefits, and outcomes should be outlined. The anesthesia team, perfusionist, cardiologist, cardiac surgery, intensivist, and should be involved to discuss the operative strategy, as well as other pertinent issues at organized weekly conferences.

The specific approach and technique selected is usually determined preoperatively, but may be changed, modified, or abandoned at the time of surgery depending on changes in the clinical status, or new, misdiagnosed, or unexpected information or findings noted at operation, or with intraoperative transesophageal (TEE) to assess the degree of valve (s) dysfunction and subsequent intraoperative evaluation of the surgical valve repair or replacement. This is especially true for mitral valve repair where the result is determined in concert with the surgeon's operative assessment that includes: competent MV on saline testing; good surface cooptation; symmetric closure where anterior leaflet occupies 80% or more of the valve area; no residual billowing; and no SAM (systolic anterior motion)[55].

Intra-operative aspects

Anesthesia[56-58]

The anesthetic considerations specific for valve surgery includes preoperative assessment, and intra-operative monitoring of arterial pressure, pulse oximetry, 5 lead ECG, non-invasive blood pressure, central venous pressure, EtCO2, (Swan Ganz pulmonary pressure, optional), temperature, urinary output, and point of care testing (glucose, electrolytes, blood gases, and coagulation studies). Access for peripheral venous, central venous and arterial catheters is the anesthesiology domain, as well as airway management (use of double lumen or bronchial blocker ET tubes for left or right chest approaches). Anesthetic drug management includes pre-induction, induction and maintenance with intravenous and inhaled agents, and muscle relaxants. Neurological monitoring is optional. This includes Near-Infrared Spectroscopy for Cerebral Oximetry monitors cerebral perfusion using regional oxygen saturation (rSO2) during cardiopulmonary bypass. This allows early identification of ischemia. The bispectral index or BIS allows any ischemic event to be identified early. The BIS (bispectral index) monitor analyzes the phase relationship between different frequency electrical components over time. It is helpful in assessing the depth of anesthesia, especially during hypothermic circulatory arrest. The 2D TEE evaluation by the anesthesiologist, cardiologist, or surgeon, before and after valve surgery, and especially mitral valve (MV) repair is crucial. It yields information regarding residual chamber air, regional and global LV/RV function, systolic anterior motion (SAM), eccentric and central jets across the MV, and MV regurgitation outside the prosthetic annuloplastic ring or band. The addition of 3D ECHO has enhanced the anatomic assessment[56-58].

Fluid and blood administration, troubleshooting during CPB, weaning from CPB, and coordination of transfer from the OR to the ICU are all overseen by anesthesia in conjunction with the perfusionist and surgeon (tables 7, 8)[56- 58].

Anesthesia Consideration for Heart Valve Surgery *

	AS	AR	MR	MS
Preload	increase	increase	increase	+/_
Afterload	decrease	decrease	decrease	Normal
Goal	Sinus rhythm	Augmentation of forward flow	Mild tachycardia	Controlled ventricular response
Avoid	tachycardia bradycardia	bradycardia	myocardial depression	tachycardia pulmonary vasoconstriction

**Cook Dj, Housmans PR, Rehfeldt KH. Valvular heart disease. In: Kaplan JA, reich DL, Lake CL, Kostadt SN, editor. Kaplan's Cardiac Anesthesia 5th ed. Elsevier Saunders. Philadelphia. 2006; p.645-690.*

Table 8. ICU Subsystem Approach/ Concerns (50).

Vital signs, Temperature, Weight, Daily input. output.
Hemodynamics- Preload, Contractility, Compliance, Afterload, HR-rhythm
Respiratory- FAST Track; Respiratory failure
Hematological- Bleeding, Coagulopathy, Anticoagulation
Renal 1cc/kilo/hour urine output minimum
Neurological- Seizure, TIA, Stoke, Pain, Delirium, Agitation
Fluid/Electrolyte – Input, Output; Potassium protocol
Infectious- Antibiotic prophylaxis
Gastrointestinal- Prophylaxis
Vascular-Access sites
Wound – Surgical wound care
Nutrition-Enteral, Parenteral maintenance
Pharmacological monitor- especially cardiac drugs
Metabolic/Endocrine/ Diabetes- Glucose protocols

Major cardiac concerns

Hypertension
LV/RV failure
AF/VF
Increase PAP
Cardiac tamponade

To avoid complications associated with banked blood product transfusion, as well as blood conservation, incorporating pre-operative autologous transfusion technique is recommended. This is performed by unassisted gravity removal of blood from a patient shortly after induction of anesthesia. Blood removal is performed simultaneously with acellular fluid replacement. This technique is recommended for use in surgical procedures with an estimated blood loss of greater than 1500 ml [59].

Cardiopulmonary Bypass (CPB)

CPB is a component of open valve surgery. The components include a heart lung machine, and the disposables (membrane oxygenator, perfusion pack, drugs, monitors, and POC testing.

CPB considerations related to valve surgery include cannulation, perfusion strategies (e.g. venous vacuum assist, "sucker bypass"), myocardial protection, and the avoidance of systemic air or particulate emboli [57,58,60]. Utilizing specific protocols for patients with malaria and sickle cell disease (avoiding hemolysis) are warranted, especially in high incidence developing countries [61, 62]. Advanced techniques for vacuum venous drainage, and HIT protocols are available but not crucial for the majority of cases [63, 64].

Myocardial protection has been well reviewed, especially cold, tepid, or warm cardioplegia techniques[65-68]. Other protection methods include systemic and local topical hypothermia, hypothermic ventricular fibrillation, direct ostial coronary perfusion, antegrade or retrograde cold, tepid, or warm cardioplegia, be it crystalloid or blood. Normothermic perfusion (warm body, cold heart) is safe and saves time. Beating heart valve surgery has been advocated by some[69]. This technique obviates the need for cardioplegia, but requires increased vigilance to avoid air or particulate emboli, as well as compromising adequate exposure of the target valve(s).

Our administration of technique for cardioplegia is via the aortic antegrade or retrograde coronary sinus route. Ten to 15 cc/kilo, or up to 1 liter is infused at 70-100 mm Hg antegrade, or <40 mm Hg retrograde. Repeat doses are given either at 20-30 minute intervals, or when ECG or observed myocardial activity is observed. LV distension must be avoided with venting. Systemic temperature is to drift, or cool to 28-34 degree centigrade.

Air emboli is a major concern for valve surgery. Flooding the operative field with CO_2 is recommended, as well as air maneuvers during weaning from CPB. TEE is useful during this stage. Vacuum venous drainage during CPB can be helpful, especially for minimally invasive procedures [63].

Incisions/Access/Exposure/Instruments/Product

The most common incision and access for closed mitral commissurotomy is the left anterior thoracotomy approach, whereas the full median sternotomy approach is used for the majority of open-heart valve procedures [70-73].

The median sternotomy approach to the mitral valve utilizing CPB has been well described[71-73]. The right thoracotomy approach to the mitral valve remains a practical operation for redo mitral or tricuspid valve surgery, and patients following previous coronary artery revascularization. Right thoracotomy is a cosmetically superior approach in children, adolescents and young women for primary mitral procedures. Aortic, mitral, and tricuspid procedures can be performed with better patient satisfaction and reduced risk at future sternotomy[74-76].

Recently, minimally invasive approaches have been described figure 10 [77-83].

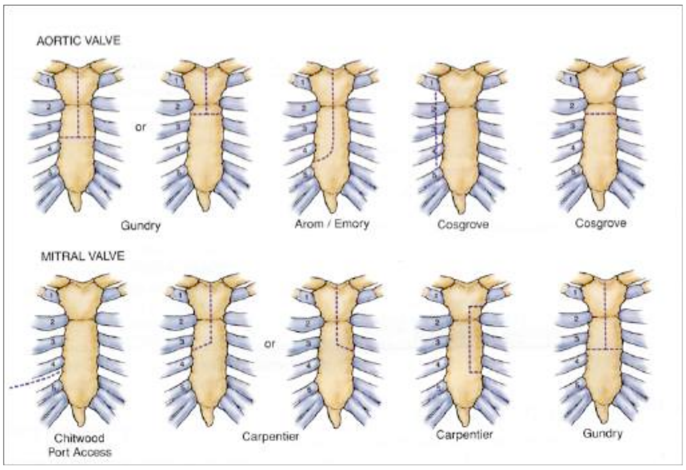


Figure 10. Minimally invasive approaches to the aortic or mitral valves. (Mack MJ, Reducing morbidity with alternative approaches. Modified from Cohen RG, Mack MJ, Fonger JD, Landreneau R. editors. Minimally Invasive Cardiac Surgery. Quality Medical Publishing Inc. St Louis, MO, 1999. P.32.)

The rationale includes cosmetic considerations, decreased incisional pain, reduced length of hospital stay, and improved convalescence. Yet long term outcomes have not been altered. Less invasive techniques must include familiarity with a variety of techniques that include A/V femoral, right internal jugular venous, and right axillary artery cannulation techniques. However, special cannulation techniques are expensive. Access for aortic valve repair can be obtained by a right anterior chest approach through the 2nd or 3rd interspace, or a midline sternal approach 5-8 cm below the angle of Louis and lateral along the right 3rd or 4th interspace. A variety of minimally invasive instruments and devices have been developed. They include:Video illumination with Zeus or DaVinci devices; specially designed retractors (e.g. Cosgrove and Chitwood aortic vascular clamps); as well as surgical instruments specific for valve surgery that include mitral valve sternal retractors, mitral valve hooks for mitral valve assessment, and special dissection scissors, and forceps (pick-ups) figures [11, 12.]

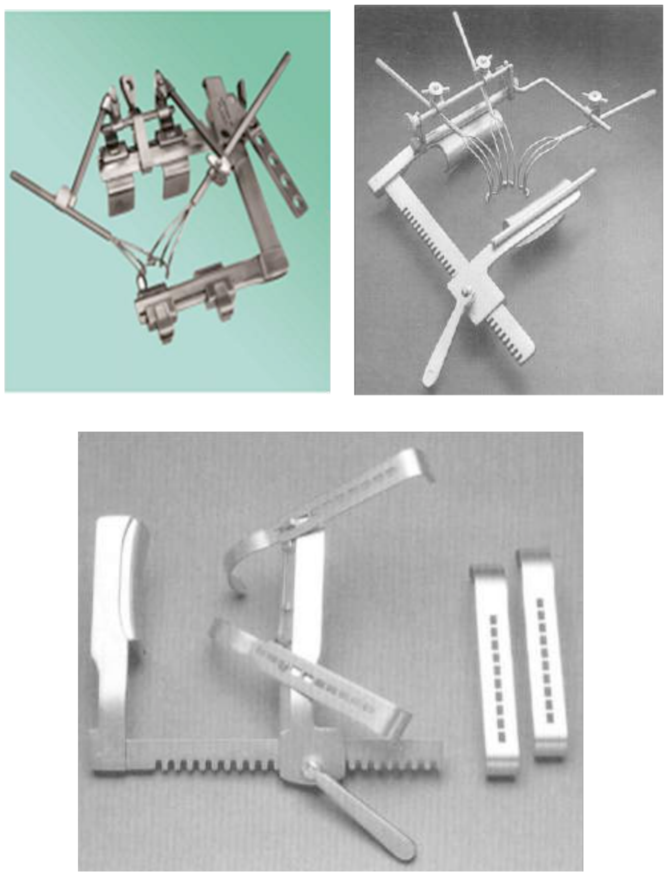


Figure 11. Carpentier/ Cosgrove/ Kuros Retractors

Figure 12. Minimally invasive instruments (scissors, needle holder, knot pusher, grabber, probe) (Photo curtesy of AT Pezzella)

A variety of prosthetic valves, rings, and bands are commercially available, along with suture (especially # 4-0 and 5-0 Gortex suture for mitral valve chordae repair), and graft material. Fresh or gluteraldehyde treated autologous pericardium (fixated with 0.6%concentration for 5-10 minutes, then rinsed with saline for 3-5 minutes), as well as heterograft pericardium, are also utilized in a variety of situations.

The selection of a prosthetic valve must consideration of the correct effective orifice area (EOA). This is ..”determined by the size of the patient’s annulus, and by the size of the prosthesis that can fit into the patient’s annulus and by the proportion of the total cross-sectional area of that prosthesis that is actually available for blood flow” [26].

Operative aspects

The major goals of surgery are to correct, improve, respect, replace, restore, repair, remove, or resolve anatomic or physiologic abnormalities, while providing adequate myocardial protection. Specific surgical techniques will be discussed in parts 4, and 5. The importance of full chordal preservation in all mitral valve operations cannot be over emphasised. Benefits include: a) reduced operative and late mortality; b) maintenance of LV geometry, size, and function; c) prevention of LV rupture; and d) improved RV function [69].

Redo operations

The incidence of redo operations in the rheumatic population is increasing, given the long-term decreased durability of mitral commissurotomy, bioprosthetic valves, and valve repair, especially in children, and adolescents. Reoperations, primarily for degeneration of bioprosthetic valves or failed MV repair, are a challenging aspect of RHD surgery.

Surgeons should close the pericardium at primary operation. It must be emphasized that conservative techniques can extend patient survival despite the need for reoperation, in comparison to survival with mechanical valves. The belief that patients with mechanical valves do not need reoperation is not true. In addition, survival to reoperation is more common in patients who have conservative procedures compared to patients with mechanical valve who die earlier due to complications.

The preoperative lateral chest x-ray documents the number of sternal wires, as well as the relation of the right ventricle and ascending aorta to the underlying sternum. As noted, a right thoracotomy approach for redo mitral valve, or tricuspid repair or replacement, is associated with fewer morbidities[74-76]. A left thoracotomy is another option when a previous median sternotomy or right thoracotomy has been performed[84]. For redo median sternotomy, femoral cannulation access may be necessary, and the use of the oscillating sternal saw is recommended. In general the heart should not be opened or the left atrium manipulated prior to placement of the aortic cross clamp.

Exposure of the mitral valve apparatus in redo operations can be improved with several technical maneuvers. Freeing up the LV adhesions allows the LV apex to rotate posteriorly. Alternatively, the right or left chest cavity can be opened when there is dense tissue adhesion. . Also, freeing up the SVC allows improved retraction of the opened left atrium[85]. For redo replacement or repair of the MV enucleation of the prosthetic valve ring or band and preservation of the annulus is crucial. The fibrous pannus on the sewing ring is carefully peeled off once a fibrous plane is established. Exposed sutures are sequentially cut and the sewing ring is slowly peeled off the native mitral annulus[85].

Postoperative aspects

The subsystem approach to the care of cardiac surgery patient in the ICU includes: cardiac, pulmonary, hematological, renal, infectious, neurological, fluid electrolyte, metabolic, and nutritional subsystems (table 9) (49-52). Continuation of medical management includes diuretics, glucose control, dietary sodium restriction, keeping electrolytes within cardioprotective ranges (potassium, calcium, magnesium), digoxin, and afterload reduction. For mechanical valve replacement procedures appropriate bridging anticoagulation with IV heparin, followed by warfarin is important until therapeutic INR range is acheived.

Dunning et al. (86) has developed a practical protocol for emergency cardiac arrest (figure 13). This is a very effective and targeted approach, especially in postsurgical cardiac patients.

Blood conservation is especially relevant, given the difficulties of procuring blood, blood products, and safety in developing countries with a high incidence of hepatitis and HIV [87, 88]. The major problems to address in the postoperative period include bleeding, pulmonary hypertension, heart failure, atrial fibrillation, coagulation protocols, and preventing endocarditis.

Bleeding is a significant concern, especially in developing countries where blood and blood products are more difficult to procure and process. Current practices for blood conservation begin with preoperative oral Iron therapy to increase the hemoglobin. Autologous pre-donation, meticulous hemostasis, retrograde priming, and return of all residual pump volume to the patient, cell saver volume, and an increased threshold for post- operative RBC transfusion can avoid blood product usage in as many as 80% of patients [87].

Table (9). Complications (89).

Classification of Complications after Thoracic Surgery

Grade Definition: Complication from any deviation from the normal postoperative course.

Minor

Grade I. Any complication without need for Pharmacological treatment or other intervention.

Grade II. Any complication that requires pharmacologic treatment or minor intervention only.

Major

Grade III. Any complication that requires surgical, radiologic, endoscopic intervention, or multi-therapy.

Grade IIIa. Intervention does not require general anesthesia.

Grade IIIb. Intervention requires general anesthesia.

Grade IV. Any complication requiring intensive care unit management and life support.

Grade IVa. Single organ dysfunction

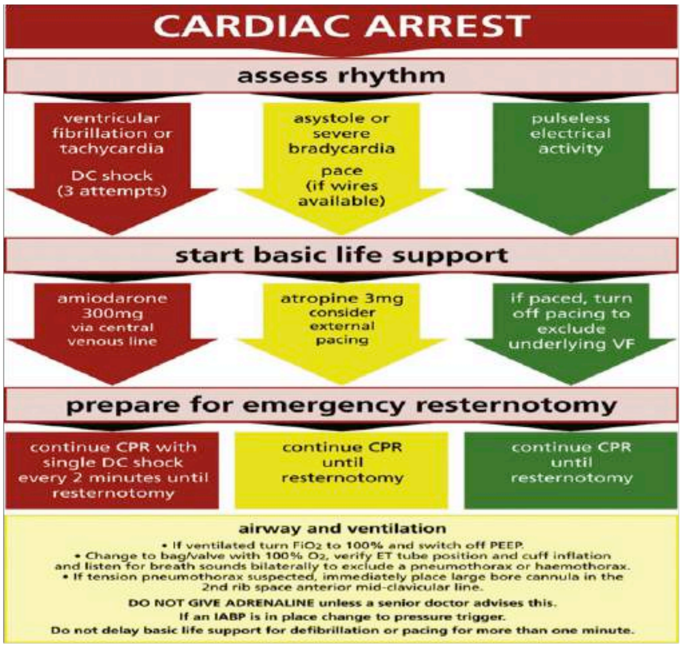


Figure 13. https://www.google.com/search?q=cals+joel+dunning&biw=1333&bih=691&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjSs-fj897LAhVELyYKHX05AUQQ_AUIBygC&dpr=0.9#imgrc=ekQjpvusUQTySM%3A (Accessed 3/30/16)

The STS has developed guidelines for prevention and treatment of bleeding issues [88]. An important recommendation is to develop a trigger for perioperative transfusion at a hemoglobin level of < 6-7 g/dL.

Complications

Specific complications in adult cardiac surgery have been well defined and reviewed. The incidence of mortality and morbidity following rheumatic valve surgery parallels non-rheumatic valve surgery. Mortality and morbidity have been defined previously [41, 42].

> " (1) all deaths, regardless of cause, occurring during the hospitalization in which the operation was performed, even if after 30 days (including patients transferred to other acute care facilities); and [2] all deaths, regardless of cause, occurring after discharge from the hospital, but before the end of the 30th postoperative day." [42]

There is no specified cardiac surgery complication classification scheme. The Clavien-Dindo classification of surgical adverse events has been proposed table 10[89].F urther classification includes: early (<30 days)/late (>60 days); acute/chronic; major/minor; common/uncommon; or rare, unusual complications. Specific results that include complications, morbidity, and mortality following RHD surgery will be discussed in Parts 4, 5.

Follow-up [90,91]

After hospital discharge it is important to monitor the patients' clinical course. There are 4 areas that warrant concern and follow-up: anticoagulation adjustment; endocarditis risk; thromboembolism or bleeding secondary to maladjustment of anticoagulant medications; and durability/ function of the prosthetic valves, especially bioprosthetic mitral valves, and surveillance of valve repair with the patients clinical clinical and 2D TTE study. A special group is the fertile females with prosthetic valves requiring anticoagulation. Monitoring and adjustment of anticoagulation is extremely important (figure 14). Early and late results and complications will be covered in parts 4 and 5.

Summary

As noted, the majority of patients with RHD live in LMIC's. Yet there is a large proportion of indigenous people and immigrants with RHD living in developed countries [91]. A continuing challenge is the late presentation or delayed referral of patients for surgical consultation and treatment. It is clear that younger patients do better with earlier mitral valve repair, especially before development of atrial fibrillation. The choice between mitral valve repair, bioprosthetic valve, or mechanical valve replacement continues to be debated. Increased experience and confidence of cardiac surgeons with valve repair is necessary and feasible. Unfortunately, there are no randomized prospective studies available, nor will there be to judge which operation is best. Specific operations, as well as operative results and complications will be discussed in parts 4 and 5.

Figure 14 [45]
VKA (vitamin K antagonists)
(http://www.uptodate.com/contents/biology-of-warfarin-and-modulators-of-inr-control
(Accessed 3/26/16).

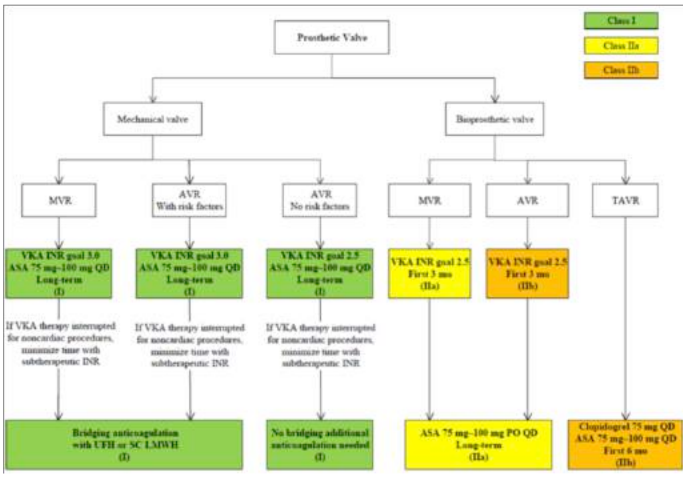


Table 1. [25] Historical Sampling of mechanical and bioprosthetic valves:
Mechanical: (Various materials used: Silicone, Teflon, Delrin, Lexan, Pyrolyte, Nitinol)

Caged Ball
- Hufnagel 1953
- Harken-Soroff 1960
- Starr/Edwards 1960-1966
- McGovern/Cromic 1962
- Smeloff/Cutter 1966
- DeBakey Surgitool 1967
- Braunwald Cutter 1968

Monoleaflet
- Non-tilting disc
- Kay Shiley 1965
- Beall Surgitool 1967
- Cooley Cutter 1971

Tilting disc
- Bjork/Shiley 1969
- (Convexo-concave) 1975
- Lillehei/Kaster 1970
- Hall-Kaster Medtronic Hall 1977
- Omniscience 1978
- Omni-Carbon 1984

Bileaflet Valves
- Gott/Daggett 1963
- Kalke-Lillehei 1968
- St Jude 1977
- Carbo-Medics 1986
- Sorin 1989
- ATS 1992
- MCRI/On-X 1996

Bioprosthetic Valves
Stented
Edwards Prima
Carpentoir Edwards Perimount,
Magna, Ease
Medtronic Hancock II, Mosaic
St Jude Biocor
Sorin Mitroflow

Stentless
T-SPV (Toronto Stentless
Porcine Valve
Sutureless
Sorin Percevel (bovine)
Medtronic 3F enable aortic
valve (equine)
Edwards Intuit (bovine)

Percutaneous (TAVI)
Edwards Sapien
Medtronic CoreValve

Homograft
Xenograft/Heterograft
Porcine aortic valve
Bovine pericardial valve

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