Review of

Cardiac Anesthesia and Cardiac Critical Care

With 2,100 MCQs

Section Editors

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Review of
Cardiac Anesthesia and Cardiac Critical Care
With 2,100 MCQs

For All Examinations in Cardiac Anesthesia and Cardiac Critical Care

DM FNB FIACTA FTEE FICCC

2nd Edition

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Section Editors

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K Muralidhar **Rajiv Juneja** **Naman Shastri**

Forewords

Navin C Nanda, Balram Airan and Randeep Guleria

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Review of Cardiac Anesthesia and Cardiac Critical Care with 2,100 MCQs

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Dedicated to

My father and family

Dr KK Malhotra
(4.7.1929–4.1.2011)

My mentor, guide and inspiration in life
An extraordinary physician and human being with boundless affection, witty, hardworking and godly qualities

Foreword

It gives me an immense pleasure to write a foreword of the Second Edition of the book *Review of Cardiac Anesthesia and Cardiac Critical Care with 2,100 MCQs* written by Dr Poonam Malhotra Kapoor of All India Institute of Medical Sciences, New Delhi, India.

It is also pleasing to see an MCQ book entirely devoted to in-depth coverage of all aspects of cardiac anesthesia with traditional topics on drugs for cardiovascular diseases to congenital heart disease, embryology and rheumatic problems of valves pertinent to the Indian subpopulation. The book also has MCQs on rapidly developing areas like extracorporeal membrane oxygenation (ECMO), critical care and echocardiography which receive good coverage in this book. Explanations to the MCQs also add value to the book.

Setting MCQs for an examination is not an easy task. The author has worked well to make them topic-wise, relevant and realistic for examination purposes. The book will be very useful to the students especially those preparing for various competitive examinations. I feel Dr Malhotra's long stint at AI1MS has honed her skills as an author and as a teacher, helping to prepare candidates for examinations in the superspecialty field of cardiac anesthesia. With her academic and research experience, she has added the freshness of a young teacher to the perspective of the book which has also been benefited tremendously by a very experienced faculty of cardiac anesthesiologists in India serving as section editors. These are Dr Yatin Mehta, Dr Deepak Tempe, Dr K Muralidhar, Dr R Gopinath, Dr Rajiv Juneja and Dr Naman Shastri. These globally renowned teachers have enriched the flavor of this objective mode of assessment in examinations. Medical students in India have been traditionally dependent on Western books for knowledge and information. However, the situation is changing now with many Indian authors publishing books in several scientific subjects but this is the first book of its kind in cardiac anesthesia and all contributors are masters in their respective topics. I myself have been an active participant as a faculty in some of the scientific conferences conducted by the Society of Cardiac Anesthesia including the Delhi and NCR Branch, under whose 'aegis' this book is being published. It is a young and vibrant academic society and it is heartening to note senior and founder members of the association coming together to fill a void in MCQ assessment by writing this book.

I congratulate the authors and hope the book gains the success that it deserves. I strongly recommend this student-friendly book to all interested in cardiac anesthesia.

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A Journal of Cardiovascular Ultrasound and Allied Techniques

Foreword

The emergence of Cardiac Anesthesia over the last few decades as a discipline has made very rapid progress on all fronts. Newer knowledge in the field of cardiac anesthesia and critical care is accumulating almost everyday, but all of it is not surely useful from the examination point of view. The difficulty lies in deciding which and how much of the advances should be included and emphasized or ignored in a book of its kind. The editor and section editors of this book deserves a great credit for the painstaking work they have put into this book and presentation of the MCQs so that the students can quickly revise their subject knowledge and remember the key points with the explanation in examinations.

While complementing Dr Poonam Malhotra Kapoor on her painstaking efforts for the second edition of 'Review of Cardiac Anesthesia and Cardiac Critical Care with 2,100 MCQs', I feel confident that the book will be useful to those who are preparing for DM, FNB, MD, FIACTA, FICCC, FTEE and other post-graduate medical entrance examinations. As the book covers a wide area of questions on hemodynamic monitoring, cardiovascular drugs, cardiac-related diseases, transesophageal and transthoracic echocardiography and procedures, like cardiopulmonary resuscitation, bronchoscopy, heart failure and sepsis, it will be a very good guide for the students and readers.

This book will prove to be a useful compendium for the medical students to take examination. I am sure this book will satisfy the needs of the medical students for whom it is essentially meant. I congratulate and wish the editor, her team and the book all the success in future.

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Foreword

The second edition of the book 'Review of Cardiac Anesthesia and Cardiac Critical Care' promotes the value of Multiple Choice Questions for the different exam-going students and junior faculties. Featuring numerous contributions from international and national experts, consultants and specialists in cardiac anesthesia and cardiac critical care is the hallmark of this book.

Though the ideal postgraduate examination still needs to be developed, currently multiple choice questions form the backbone of most examinations. This review book with explanation with a special section on echocardiography has been very successful in the first edition of the book itself! With multiple choice questions, it is possible, in a short time, to revise and test a wide range of knowledge and also it is not time-consuming to mark. The book begins with a section on cardiovascular anesthesia. Different sections deal with anatomy and physiology, embryology, cardiovascular drugs, cardio-related disease, transesophageal echocardiography, transthoracic echocardiography and many of the miscellaneous procedures like cardiopulmonary resuscitation, hemodynamic monitoring, bronchoscopy, ACLS, BLS, difficult airway, heart failure and sepsis. The features, strengths and weaknesses are presented in the form of MCQs to help and fulfil the requirements for attempting the examinations. The downside with the MCQs is that the uniformity of making of MCQs is difficult to achieve.

MCQ books are, in the present era, achieving respectability among students and faculties worldwide. This book assists both novice and experienced workers in the field to learn from established practitioners in the field of cardiac anesthesia and cardiac critical care.

The book will continue to stimulate you from beginning to end and going through the book with its numerous explanations is a pleasure. The authors of the book are unmatched in their skills that have excelled in their fields.

I am sure the book will find a permanent place on the desk of all students and junior faculties interested in taking the examinations. I congratulate Dr Poonam Malhotra Kapoor and her team for this wonderful endeavor and wish the book a great success.

Randeep Guleria MD DM
Director
All India Institute of Medical Sciences (AIIMS)
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Preface

The second edition of *Review of Cardiac Anesthesia and Cardiac Critical Care with 2,100 MCQs* is a tribute to the students in the operation room and cardiac ICU, dealing with the cardiac surgical patients. New enroads in understanding complex concepts and tackling quantitative problems associated with cardiac anesthesia and cardiac critical care have come up in recent times. This highly effective, enjoyable and affordable review tool is not only ideal for those taking the examinations; it is also a great overview for anyone looking to stay up-to-date in this subject which is gaining increasing importance in recent times. This book offers the following advantages, to its readers:

Cardiac anesthesia for noncardiac surgery and patient safety outcomes, following cardiac are additional chapters to help the clinician and intensivists manage redo, difficult cases. Hope you all enjoy the book and its format to enable you to take the examination(s) well prepared. Get a detailed explanation of all examination-based 2D and 3D echocardiography, questions **clarify difficult concepts and problems** with more than 100 videos.

Examination on any subject is a must for progress. The backbone of any examination today is multiple choice questions. They guide the examinees toward the examination trends. The book is a powerful and most welcome statement about the place of examination trending in the evolving and ever-growing subject of cardiac anesthesia and the 3 sections have contributors as section editors from renowned names in cardiac anesthesia like Dr Yatin Mehta, Dr Deepak Tempe, Dr R Gopinath, Dr K Muralidhar, Dr Rajiv Juneja and Dr Naman Shastri. I shall always remain indebted to each of them for their contribution.

The book is a compilation of echocardiography information and transesophageal echocardiography (TEE) stills and videos from perioperative TEE and transthoracic echocardiography (TTE) with explanations in Section 2 and about 276 questions in Section 3 on upcoming topics like critical care and ECMO.

Competing technology, miniaturization, real time 3D TTE and TEE, extracorporeal membrane oxygenation (ECMO) (Perioperative and postoperative), critical care and infection control are modern tools of cardiac anesthesia, which have enhanced the position of a cardiac anesthetist from a mere giver of drugs to a perioperative physician performer doing activities like performing local, GA and hemodynamic monitoring, pain relief and patient outcome monitor measures in ICU—making him all incharge of the patient. Also, with the growing field has come a growth in examinations. The book aims at the latter with videos, tables and figures in a simplistic manner for each of the 40 chapters. Explanation in the echocardiography section, makes Section 2—easy and good reading. I hope you enjoy the basic book on Review of Cardiac Anesthesia with 2,100 MCQs which is informative and easy-to-use.

I am sure, the book will fully meet the requirements of students preparing for all examinations in cardiac anesthesia like DM, FNB, FIACTA and perioperative TEE examinations.

Poonam Malhotra Kapoor

Acknowledgments

I would like to thank all section editors and contributors for their invaluable efforts and the numerous hours they spent preparing the manuscript while attending to increasingly busy clinical practices.

I thank my Head of the Department Prof Usha Kiran and the Dean of AIIMS and Chief, cardiothoracic Centre, AIIMS for their continuous and encouraging support toward this academic venture.

Words are inadequate to thank my office staff at AIIMS, consisting of Sandeep Kumar, Sachin, Poonam Meena and Manoj Mishra for their continuous, laborious help in compiling this book. Without their ongoing enthusiastic efforts this book would not have seen this day. I would especially like to thank Dr Yatin Mehta, Dr Naman Shastri, Dr Varun Kapoor and Pranav kapoor who inspired me into putting this book together.

I would like to acknowledge the residents of Cardiac Anesthesia Department, All India Institute of Medical Sciences, New Delhi, India and students of FICCC and those seeking Fellowship examinations in TEE for providing the much-needed stimulus that animated my efforts.

My family whom, I take for granted every second and my senior and junior colleagues in the Cardiac Anesthesia Department, All India Institute of Medical Sciences, New Delhi, India, deserve a heartfelt "Thank you". The SCA-Delhi and NCR Branch is an ever-growing Banyan tree founded by Professor Nita Saxena and Dr Yatin Mehta, under whose aegis, academics and research will also flourish. Seniors like them, are rare. My good luck.

Finally, I would like to express my gratitude to Mr Jitendar P Vij (Group Chairman), Mr Ankit Vij (Group President), Ms Chetna Malhotra Vohra (Associate Director–Content Strategy), Ms Nedup Denka Bhutia and the staff of Jaypee Brothers Medical Publishers for their guidance in making this book.

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SECTION 2: Perioperative TEE and Transthoracic Echocardiography

SECTION 3: Extracorporeal Membrane Oxygenation and Critical Care

CHAPTER 17

Echocardiography for Prosthetic Valves

1. A diagnosis of patient prosthesis mismatch (PPM) is made in a 32-year-old woman with prior aortic valve replacement for a congenitally bicuspid aortic valve complicated by severe aortic regurgitation. The basis for this diagnosis is:
   a. A mechanical valve has been selected for a female patient in whom pregnancy is planned
   b. A mechanical valve has been selected for a patient with a history of drug abuse
   c. The valve implanted is too small for this patient
   d. The valve implanted is too large for this patient
   e. A bioprosthesis has been selected for a young patient

2. A 55-year-old man with prior aortic valve replacement presents with dyspnea on exertion, which has been present since his surgery. The PPM is suspected. Which of the following criteria is used to define this syndrome?
   Effective orifice area (EOA) corrected for body surface area:
   a. ≤0.55 cm^2/m^2
   b. ≤0.65 cm^2/m^2
   c. ≤0.75 cm^2/m^2
   d. ≤0.85 cm^2/m^2
   e. ≤0.95 cm^2/m^2

3. An 11-year-old boy had a 19 mm bileaflet mechanical aortic valve implanted for severe aortic stenosis on the basis of a congenitally bicuspid valve. On echocardiographic evaluation, the peak transvalvular velocity was 3.5 m/sec. However, at catheterization the left ventricle (reached by transseptal puncture) to aortic gradient was only 25 mm Hg. What is the most likely explanation for this discrepancy?
   a. At catheterization, the aortic valve gradient could not be measured by pullback
   b. The cardiac output was higher at the time of catheterization than at the time of the echocardiogram
   c. The pressure recovery phenomenon has resulted in overestimation of the aortic valve gradients by Doppler
   d. The aortic valve gradients have been overestimated because a mitral regurgitant spectrum was confused with the aortic valve spectrum
   e. The valve is too small for this patient

Answers: 1. c 2. d 3. c

4. A 72-year-old man who had a ball and cage (Starr-Edwards) mitral valve implanted 20 years ago is followed echocardiographically. In echocardiogram of patients with this type of prosthesis, the size of the ball is:
   a. Overestimated because of faster propagation of sound in the ball relative to that in tissue
   b. Overestimated because of slower propagation of sound in the ball relative to that in tissue
   c. Underestimated because of faster propagation of sound in the ball relative to that in tissue
   d. Underestimated because of slower propagation of sound in the ball relative to that in tissue
   e. Accurately represented
5. A 55-year-old man with a recent aortic valve replacement undergoes postoperative echocardiography to establish baseline values for the valve. A peak velocity of 2.5 m/sec is recorded. This value is:
   a. Abnormally high suggesting PPM
   b. Abnormally high suggesting prosthetic valve stenosis
   c. May be normal depending on the size and type of the valve
   d. Low suggesting that the valve is a homograft valve
   e. Abnormally low suggesting that the patient has a reduced cardiac output
6. A 63-year-old patient with prior bioprosthetic mitral valve replacement undergoes an echocardiographic evaluation. The mean transvalvular gradient is 10 mm Hg. To interpret this result, which of the following patient information is most important?
   a. Height
   b. Weight
   c. Heart rate
   d. Blood pressure
   e. Gender
7. A 71-year-old patient with a bileaflet mitral valve prosthesis undergoes a transthoracic echocardiographic evaluation with harmonic imaging. In the apical views, microcavitations (spontaneous microbubbles) are seen in the left ventricle. This finding is most consistent with:
   a. Hemolysis
   b. Paravalvular regurgitation
   c. Imaging artifact
   d. A patent foramen ovalis
   e. Normal prosthetic function
8. An 82-year-old man with a bioprosthetic aortic valve prosthesis undergoes an echocardiographic evaluation. Which of the following is the formula for calculating EOA?
   a. Stroke volume/prosthetic velocity-time integral (VTI)
   b. (Stroke volume × heart rate)/peak transvalvular velocity
   c. Subvalvular VTI/prosthetic VTI
   d. Subvalvular peak velocity/peak transvalvular velocity
   e. (Subvalvular VTI × stroke volume)/prosthetic VTI
9. A 12-year-old boy with a history of aortic valve replacement undergoes an echocardiographic evaluation. The peak velocity across the prosthesis is 3.5 m/sec. In which of the following valves is pressure recovery most likely to be a consideration?
   a. Bileaflet
   b. Tilting disc
   c. Homograft
   d. Bovine stented bioprosthesis
   e. Stentless bioprosthesis

Answers: 4. b 5. c 6. c 7. e 8. a 9. a

10. A 15-year-old boy who had bioprosthetic aortic valve replacement for a congenitally bicuspid aortic valve undergoes an echocardiographic evaluation. The peak velocity across the prosthesis is 3.5 m/sec. Which of the following is most supportive of the diagnosis of prosthetic valve stenosis?
    a. The bioprosthetic cusps are thickened with reduced mobility
    b. The size of the valve is 19 mm
    c. The aortic root is dilated
    d. The patient's hematocrit level is 45%
    e. The patient's left ventricular ejection fraction is 32%

11. A 72-year-old woman with a bioprosthetic mitral prosthesis undergoes an echocardiographic evaluation. Which of the following statements is true?
    a. EOA calculated as 220/pressure half time provides the best single measurement of functional valve area
    b. EOA calculated as 270/pressure half time provides the best single measurement of functional valve area
    c. EOA calculated as 1.5 × (220/pressure half time) provides the best single measurement of functional valve area
    d. EOA calculated as 150/pressure half time provides the best single measurement of functional valve area
    e. EOA calculated by the pressure half time method is inaccurate in patients with mitral prostheses

12. A 63-year-old patient with prior bioprosthetic mitral valve replacement undergoes an echocardiographic evaluation. In which of the following valves is a large central jet most consistent with normal valve function?
    a. Starr-Edwards ball and cage valve
    b. St. Jude bileaflet valve
    c. Medtronic-Hall single-disc valve
    d. Bovine pericardial bioprosthesis
    e. Porcine bioprosthesis

13. A 63-year-old patient with prior aortic valve replacement undergoes an echocardiographic evaluation for new symptoms of dyspnea. In addition to recording peak and mean gradients, the dimensionless index is calculated as:
    a. (Stroke volume × heart rate)/peak transvalvular velocity
    b. Subvalvular VTI/prosthetic VTI
    c. (Subvalvular VTI × stroke volume)/prosthetic VTI
    d. Calculated EOA/factory-specified normal EOA

14. An 81-year-old woman with prior bioprosthetic mitral valve replacement is noted to have a new systolic murmur and evidence of congestive heart failure. Transthoracic echocardiographic evaluation reveals only trace central mitral regurgitation. Which of the following statements is correct?
    a. Transesophageal echocardiography (TEE) is essential to evaluate the patient for paravalvular regurgitation
    b. A peak transmitral velocity of 2 m/sec argues against undetected paravalvular regurgitation
    c. A mean transmitral gradient of 10 mm Hg argues against undetected paravalvular regurgitation
    d. Normal (S dominant) pulmonary venous flow excludes the possibility of paravalvular regurgitation
    e. Paravalvular regurgitation is best detected in the apical three-chamber view

Answers: 10. a 11. e 12. b 13. b 14. a

15. A 22-year-old man presents for echocardiographic follow-up 10 years after a Ross procedure. A 3/6 murmur is heard. What complication is the echocardiogram most likely to demonstrate?
    a. Aortic homograft stenosis
    b. Aortic autograft stenosis
    c. Aortic autograft regurgitation
    d. Aortic homograft regurgitation
    e. Pulmonary autograft regurgitation

16. A 72-year-old woman with prior mitral valve replacement is noted to have a new systolic murmur. An echocardiogram is obtained. Based on Figure 17.1, what is the diagnosis?

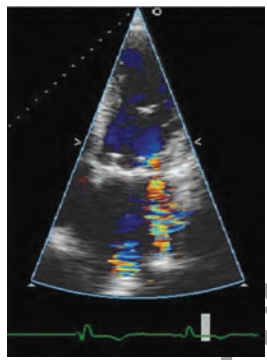
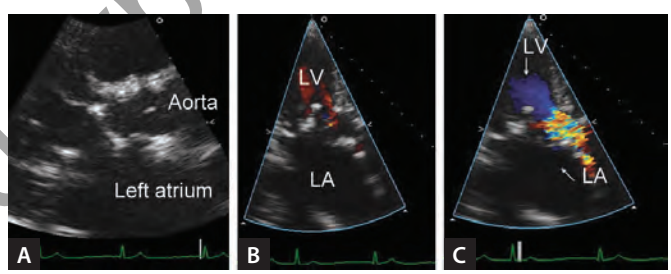


Fig. 17.1

    a. Bioprosthesis with paravalvular mitral regurgitation
    b. Bileaflet prosthesis with paravalvular mitral regurgitation
    c. Bioprosthesis with valvular mitral regurgitation
    d. Bileaflet prosthesis with normal closure jets
    e. Bileaflet prosthesis with valvular regurgitation

17. A patient with recent bioprosthetic mitral valve replacement for endocarditis undergoes echocardiographic evaluation because of persistent fatigue and a loud murmur. Based on these parasternal (A) and apical long-axis views (B and C) in Figure 17.2, what is the most likely diagnosis?

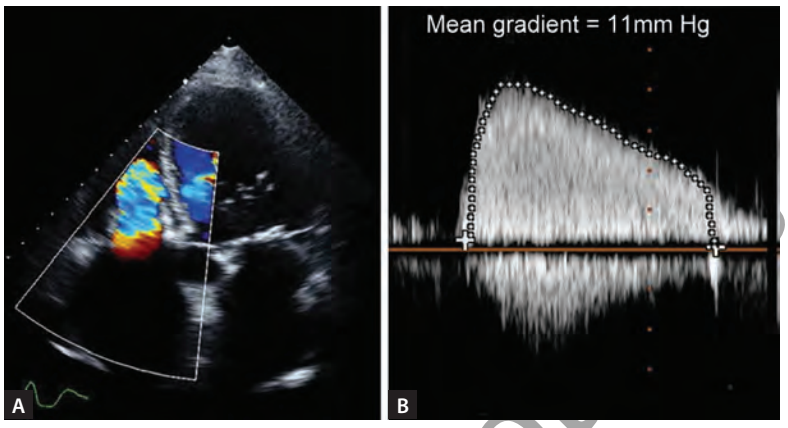


Figs. 17.2A to C

    a. Severe paravalvular mitral regurgitation
    b. Severe valvular mitral regurgitation
    c. Left ventricular outflow tract (LVOT) obstruction due to mitral systolic anterior motion
    d. LVOT obstruction due to malalignment of the prosthesis
    e. Prosthetic mitral stenosis

Answers: 15. c 16. a 17. d

18. A 65-year-old woman underwent tricuspid valve replacement for traumatic flail tricuspid valve caused by acceleration-deceleration injury in a car accident. Two years later, she presented with peripheral edema. Transthoracic echocardiography was performed. The images in Figures 17.3A and B were recorded at a heart rate of 55 bpm and a blood pressure of 120/75 mm Hg. With which of the following diagnoses are these most consistent?



Figs. 17.3A and B

a. *Normal tricuspid prosthetic function:* High output state
b. *Normal tricuspid prosthetic function:* Pressure recovery
c. Mild tricuspid prosthetic stenosis
d. Moderate tricuspid prosthetic stenosis
e. Severe tricuspid prosthetic stenosis

19. A 52-year-old man with prior mitral valve surgery undergoes three-dimensional (3D) transesophageal echocardiogram (TEE) following a suspected neuroembolic event (Fig. 17.4). What type of procedure has the patient undergone?

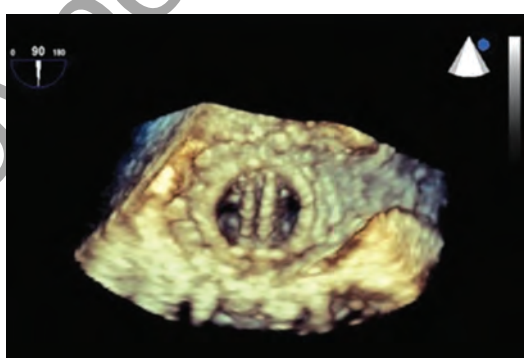


Fig. 17.4

a. Mitral ring annuloplasty
b. Alfieri stitch valvuloplasty
c. Tilting disc mitral valve replacement
d. Bileaflet mitral valve replacement
e. Mitral homograft replacement

Answers: 18. e 19. d

20. A 67-year-old man has undergone prior valve surgery. Based on the echocardiogram (ECG) in Figure 17.5, what is the most likely diagnosis?

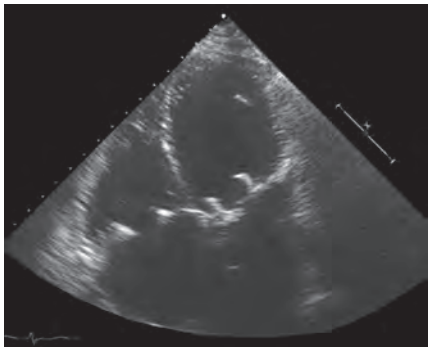


Fig. 17.5

a. Normal mitral and tricuspid ring repair
b. Normal mitral bioprosthesis, tricuspid ring dehiscence
c. Normal mitral bioprosthesis and tricuspid ring
d. Normal mitral bioprosthesis, pacer lead in the right ventricle
e. Normal mitral bioprosthesis, tricuspid vegetation

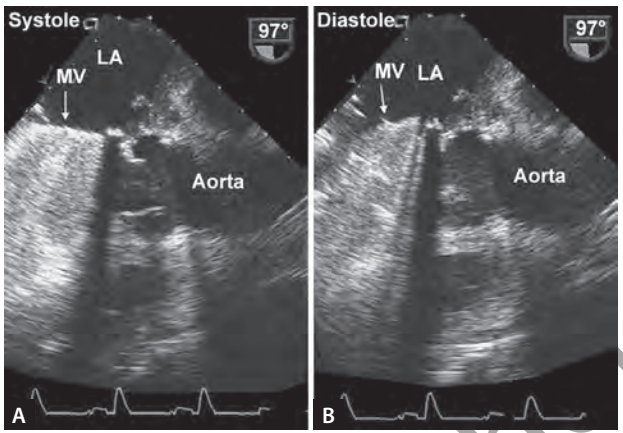
21. A 21-year-old man with recent aortic homograft valve replacement experiences a headache preceded by visual field deficits and undergoes a TEE to rule out a cardiac source of embolus. He has been afebrile and Doppler evaluation reveals only trace aortic regurgitation. Based on the echocardiographic image in Figure 17.6, what would be an appropriate next step in management?

Fig. 17.6

a. Initiate broad-spectrum antibiotics
b. Urgent reoperation
c. Refer for computed tomography evaluation
d. Refer for coronary angiography
e. Provide reassurance that the appearance of the valve is normal

Answers: 20. b 21. e

22. A 62-year-old woman undergoes mitral valve surgery. What type of prosthesis is shown on the perioperative transesophageal echocardiogram (TEE) in Figures 17.7A and B?



Figs. 17.7A and B

a. Tilting disc
b. Bileaflet
c. Trileaflet
d. Ball and cage
e. Disc and cage

23. A 75-year-old man with prior aortic valve replacement undergoes an echocardiographic evaluation because of dyspnea on exertion (Fig. 17.8). The pulsed Doppler spectrum recorded in the LVOT yields a peak modal velocity of 1.1 m/sec. Continuous-wave Doppler recorded across the LVOT (and valve) yields a peak velocity of 3.3 m/sec. The LVOT diameter is 2.0 cm. The calculated dimensionless index is:

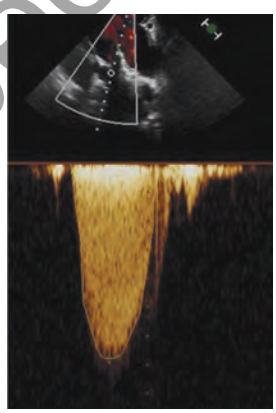


Fig. 17.8

a. 3.0
b. 1.05
c. 0.75
d. 0.5
e. 0.33

Answers: 22. a 23. e

24. A 32-year-old man with a prior history of aortic valve surgery undergoes TEE because of suspected aortic dissection. Based on the echocardiographic image in Figure 17.9, what type of procedure was performed?

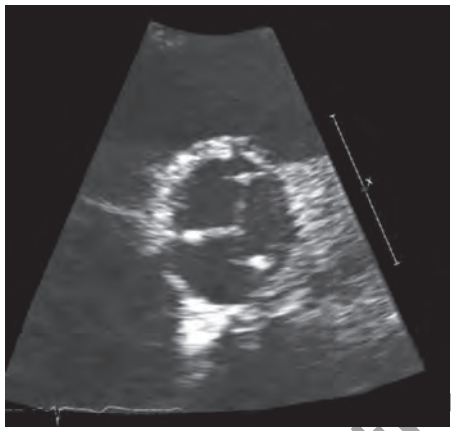


Fig. 17.9

a. Stentless bioprosthesis replacement
b. Aortic homograft replacement
c. Aortic autograft replacement
d. Stented bioprosthesis replacement
e. Aortic valve repair

25. A 66-year-old woman undergoes a resting transthoracic echocardiographic evaluation following an episode of chest pain. What is the most likely explanation for the echodensity identified by the arrow in Figure 17.10?

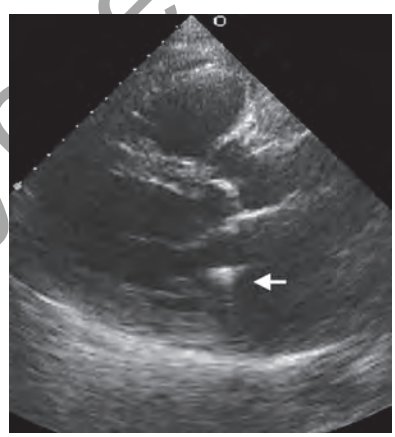


Fig. 17.10

a. Aortic prosthesis reverberation artifact
b. Aneurysm of the interatrial septum
c. Biventricular pacing lead
d. Alfieri stitch
e. Dehisced mitral ring

Answers: 24. d 25. e

Answers

1. c. The term patient prosthesis mismatch (PPM) refers to the situation in which the effective orifice area (EOA) of a prosthesis is too small relative to the patient's body size resulting in abnormally high postoperative gradients. Although bioprostheses rather than mechanical valves are generally selected for women anticipating pregnancy as well as for patients with a prior history of drug abuse, these situations are not considered PPM. Children with prosthetic valves may outgrow their valves and develop PPM but this may be unavoidable regardless of whether a mechanical versus a bioprosthetic valve is implanted.
2. d. PPM refers to the situation in which the EOA of a prosthesis is too small relative to the patient's body size resulting in abnormally high postoperative gradients. The cut off for PPM has been established to be a body surface area (BSA)-indexed EOA of ≤0.85 cm^2/m^2 on the basis of the observation that at smaller areas there is a rapid increase in transvalvular gradients. BSA-corrected EOA ≤0.65 cm^2/m^2 is considered severe PPM. The major adverse outcomes associated with PPM are reduced short-term and long-term survival, particularly if associated with left ventricular (LV) dysfunction. The high gradients associated with PPM may be distinguished echocardiographically from prosthetic valve dysfunction by comparing the echocalculated EOA with published normal values for individual valves and by excluding imaging evidence of valve dysfunction.
3. c. Pressure recovery refers to the situation in which there is a localized pressure drop at the central orifice of a bileaflet mechanical valve that is partially recovered distally as flow from the lateral two orifices merges with the central flow jet. Since Doppler records the maximal pressure drop, it will yield a gradient higher than that measured at catheterization with catheters placed proximal and distal to the valve. Clinical significant pressure recovery is most often encountered in the setting of small bileaflet valves in the aortic position particularly when the cardiac output is increased.
    a. Is incorrect because the direct measure of left ventricle to aorta gradients used in this patient Is superior to the pullback approach. It would be dangerous to attempt to cross this valve retrograde.
    b. Is incorrect because a relatively higher cardiac output at catheterization would result in a relatively higher (not lower) transvalvular gradient.
    c. Although it is may be possible to mistake a mitral regurgitant for a transaortic Doppler spectrum, the peak MR velocities are typically much higher than 3.5 m/sec (49 mm Hg) reflecting large gradients from the left ventricle to left atrium.
    d. In the case of PPM, elevated gradients are noted both by echocardiography and by catheterization.
4. b. Echocardiographic displays are calibrated on the basis of the velocity of sound through tissue, assuming that only tissue will be encountered by the ultrasound beam. The speed of sound in a Starr-Edwards valve ball is slower than that in tissue. Consequently, the ball is misrepresented echocardiographically as being larger than it actually is.
5. c. Although there is significant variability in the normal values reported for aortic prosthetic valves depending on size and valve type, a peak velocity of 2.5 m/sec is well within the normal range for many valves, and as such, would not be helpful in determining the type of prosthesis that has been implanted. In general, velocities of >3.0 m/sec prompt concern about pathologic elevation due to a variety of causes including PPM and intrinsic valve pathology although velocities of >3 m/sec may be normal for some valves. Stroke volume as an index of cardiac output is measured by the velocity-time integral (VTI) of the pulsed Doppler spectrum of the left ventricular outflow tract (LVOT).
6. c. Gradients across mitral and tricuspid prostheses are very heart rate dependent. Although a mean gradient of 10 at a heart rate of 60 bpm would be abnormal, the same gradient at a heart rate of 120 bpm would be "normal" for most mitral prostheses. While height and weight (choices A and B)

and calculated BSA are important in evaluating patients for PPM (BSA-indexed EOA <1.15 cm^2/m^2), this assessment requires the calculation of EOA, which is not possible with only mean gradient. It is important to record blood pressure (choice D) at the time of echocardiography for patients with mitral disease. However, its major impact is on regurgitation rather than stenosis. Gender has no direct impact on valve gradients.

7. e. With harmonic imaging, microcavitations are frequently seen with normally functioning mechanical valves. Although their origin is uncertain, they are not imaging artifacts. In the era of fundamental imaging, microcavitations were reported as markers of hemolysis, which may be a feature of paravalvular regurgitation. In the absence of intravenously injected microbubbles, a patent foramen ovalis and associated right-to-left shunt will not result in left-sided microbubbles.
8. a. EOA is calculated using the continuity equation and is equivalent to the calculation of valve area in native valves. Thus choices B and C represent formulae that can be used to calculate the dimensionless index. By comparing calculated EOA with published norms, the diagnosis of prosthetic stenosis can be established.
9. a. See also discussion of question 3. Pressure recovery is typically encountered in small bileaflet or ball and cage valves.
10. a. Imaging features of restricted thickened cusps support the diagnosis of prosthetic stenosis as the basis for the elevated gradients. A small valve (19 mm Hg) as in choice B may be associated with elevated gradients even in a structurally normal valve if there is PPM (the valve is too small for the patient). The aortic root may be dilated (choice C) in patients with native aortic valve disease and does not regress following aortic valve replacement in the absence of aortic reconstructive surgery. Choice D: The normal hematocrit excludes anemia-associated high output, which may be associated with elevated gradients in structurally normal valves. Choice E: Reduced LV ejection fraction is typically associated with low gradients and provides no explanation for the elevated gradients noted here.
11. e. The pressure half time should not be used to calculate EOA in patients with prosthetic valves.
12. b. All mechanical prosthetic valves have physiologic "regurgitation" that consists of a closing volume (a displacement of blood caused by the motion of the occluder) and leakage at the perimeter of or at hinge points of the occluders. Studies have shown bileaflet mechanical valves (St. Jude) to have the largest degree of physiologic regurgitation with central as well as peripheral jets. While Medtronic-Hall valves also have central and peripheral jets, the total amount of regurgitation is less compared to St. Jude valves.
13. b. The dimensionless index is defined as the ratio of subvalvular VTI or peak velocity to prosthetic VTI or peak velocity, respectively. It is particularly useful when image quality precludes accurate measurement of the LVOT as is needed to calculate EOA.
14. a. Because of acoustic shadowing and the eccentricity of paravalvular jets, transthoracic echocardiography is relatively insensitive for paravalvular regurgitation. Thus, transesophageal echocardiography (TEE) is indicated whenever paravalvular regurgitation is suspected. Elevated mitral gradients B and C favor mitral regurgitation. When jets are eccentric, normal (S dominant) flow may be preserved in pulmonary veins remote from the jet. All apical views should be used to assess for paravalvular regurgitation but no single view is ideal.
15. c. The Ross procedure consists of a moving the patient's pulmonary valve to the aortic position (aortic autograft) and placing a homograft (cadaveric) valve in the pulmonic position (pulmonary homograft). Of the possible correct answers (aortic autograft stenosis or regurgitation), aortic regurgitation is the most common.
16. a. The prosthesis is identifiable as a stented bioprosthesis by the presence of clearly demarcated stents. There is a mitral regurgitant jet that clearly originates outside the sewing ring and extends to the back of the left atrium: this is paravalvular regurgitation. Although the image has not been optimized for proximal isovelocity surface area (PISA) based quantitation, note the clearly demarcated PISA shell. Although spontaneous valve dehiscence may occur, hemodynamically significant new paravalvular jets raise the possibility of endocarditis as the cause.

17. d. In the parasternal long-axis view and in the diastolic frame from the apical long axis, the mitral struts are seen abutting the interventricular septum. The systolic frame shows turbulent flow in the LVOT at the level of the mitral struts. Although rare, such malpositioning of high-profile mitral prostheses may cause significant LVOT obstruction. Patients at greatest risk are those with small hypertrophied ventricles. Mitral systolic anterior motion and LVOT obstruction may be a complication of mitral repair but not mitral valve replacement. Notably in patients with mitral valve replacement for active endocarditis, the mitral chords and leaflets are typically not preserved. Mitral stenosis would be associated with high-velocity flow in diastole not systole. There is no evidence of mitral regurgitation (high-velocity flow is in the LVOT not left atrium).
18. e. Although there are no large series of published normal values for tricuspid prosthetic gradients, the existing literature supports the diagnosis of prosthetic tricuspid stenosis whenever the mean gradients are more than 6 mm Hg. The mean gradient of 11 mm Hg at a slow heart rate is consistent with severe prosthetic stenosis. It is unlikely that this patient has a high output state with a heart rate of 55 bpm and even a significantly elevated cardiac output would unlikely be associated with gradient elevation of this degree. Pressure recovery does not occur with large bioprosthetic valves in the tricuspid position. Note that the pressure half time method has not been validated for prosthetic tricuspid valves and should not be used.
19. d. This is the typical three-dimensional (3D) view of a bileaflet mechanical mitral prosthesis as seen from the left atrial perspective. Two orifices are identified in this diastolic frame with the occluders in the open position.
20. b. Mitral struts are clearly seen, identifying this valve as a bioprosthesis. On the right side, the septal leaflet of the tricuspid valve is seen in the open position with the dehisced portion of a tricuspid ring seen floating in the tricuspid inlet. The ring is appropriately attached laterally, identifying the normally attached portion of the ring. This helps prevent mistaking the dehisced portion for either a vegetation or pacer lead. This patient had severe tricuspid regurgitation.
21. e. Aortic homografts are treated cadaveric aortic roots and valves to which the native coronary arteries are implanted. The native aorta may be used to wrap the homograft aorta (the inclusion technique) or resected. Particularly when the inclusion technique is used, the normal postoperative appearance is one of a variably thickened root that may be in part due to hematoma. Over time, this resorbs and the appearance of the valve resembles that of the native aortic valve. In a clinical scenario suggestive of endocarditis, it may be impossible to differentiate a normal homograft from abscess. However, the postimplantation perioperative TEE can be very helpful in resolving this dilemma. In the absence of clinical features of infection, the appearance shown here can be interpreted as normal.
22. a. This is a typical appearance for a tilting disc mechanical mitral prosthesis. The disc pivots from an eccentric pivot point and closure is associated with a prominent central jet. This valve should not be confused with bileaflet or ball/disc and cage valves examples of which are provided elsewhere in this chapter. There are no trileaflet mechanical valves.
23. e. The dimensionless index is the ratio of subvalvular VTI or peak velocity to prosthetic VTI or peak velocities respectively (= 1.1/3.3). It is easily performed and an alternative to EOA when the LVOT diameter is difficult to measure.
24. d. This short-axis image shows three stents and cusps in the closed position. This appearance is typical of a stented bioprosthesis. Stents are not elements of homografts or autografts, which are human valves or stentless heterograft bioprostheses. Aortic repairs are also not associated with stents. Stented valves are the most common type of bioprosthesis.
25. e. The arrow indicates a dehisced mitral ring. The anterior rim of the ring is seen in a normal position adjacent to the aortic root. This patient had severe posteriorly directed mitral regurgitation. Alfieri stitches are seen in the left ventricle, tying together the A2 and P2 scallops. The LV lead of biventricular pacing is placed in the coronary sinus. The aortic valve in this patient is a native valve. Although atrial septal aneurysms may project into the left atrium and be visible from this window, they do not appear as discrete echodensities as is seen here.