Introduction to the Second Revision

The first edition of the “Guidelines for Perioperative Cardiovascular Evaluation and Management for Noncardiac Surgery” was created in 2002,1 and was revised after five years.2 As more and more elderly patients undergo surgery, and techniques for diagnosis and treatment of cardiovascular disorders have advanced substantially, the second revision has become necessary.

In this second revision, the guidelines were revised substantially in terms of the positioning of coronary interventions for patients undergoing non-cardiac surgery, especially those using drug-eluting stents (DES), and aortic stent grafting, and how to use these new techniques with conventional procedures. Guidelines for other cardiovascular disorders were revised to reflect new findings.

As the credibility of randomized clinical studies on the perioperative use of beta blockers, such as the Dutch Echocardiographic Cardiac Risk Evaluation Applying Stress Echocardiography (DECREASE) study,2a was questioned2b and became a major issue, the American College of Cardiology and American Heart Association revised their ACC/AHA guidelines on the perioperative use of beta blockers for patients undergoing noncardiac surgery in August 2014. At the same time, the European Society of Cardiology and the European Society of Anesthesiology also revised their ESC/ESA guidelines on this matter.3,4 The guidelines for the use of beta blockers were revised in this version according to the above guidelines.

Released online January 20, 2017
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This English language document is a revised digest version of Guidelines for perioperative cardiovascular evaluation and management for noncardiac surgery reported at the Japanese Circulation Society Joint Working Groups performed in 2014 (Website: http://www.j-circ.or.jp/guideline/pdf/JCS2014_kyo_d.pdf).
Refer to Appendix 1 for the details of members.
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1. Introduction

As the population ages, more elderly patients are undergoing surgery. An increasing number of patients with heart disease are undergoing noncardiac surgery, and guidelines for perioperative cardiovascular evaluation and management for patients undergoing noncardiac surgery have become necessary. The Committee on Preparation for the “Guidelines for Perioperative Cardiovascular Evaluation and Management for Noncardiac Surgery” was established in 2001 at the request of the Scientific Committee of the Japanese Circulation Society.

While the ACC/AHA Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery published in 2007 highlighted the perioperative management of patients with ischemic heart disease, our guidelines were intended to comprehensively describe ischemic heart disease and other common heart diseases which physicians often encounter during noncardiac surgery, and include risk management during pregnancy and delivery. In the present guidelines, the evidence and general agreement on the efficacy of diagnostic and treatment procedures are classified into Class I to III to help practitioners use the guidelines efficiently.

Classification of Recommendations

- **Class I:** Conditions for which there is evidence for and/or general agreement that the procedure/treatment is useful.
- **Class II:** Conditions for which there is conflicting evidence regarding the usefulness of a procedure/treatment.
- **Class IIa:** Weight of opinion is in favor of usefulness.
- **Class IIb:** Conditions for which there is evidence for and/or general agreement that a procedure/treatment is not useful.
- **Class III:** Conditions for which there is evidence and general agreement that a procedure/treatment is not useful.

However, it is quite difficult to conduct prospective randomized clinical studies in patients undergoing surgery, who are often in critical condition, and the data from such studies are also limited in many countries. Please note that the data obtained in this area of study described in the present guidelines may include many biases.

2. Outline of Diagnosis and Evaluation

In order to determine treatment strategies of noncardiac surgery and obtain information necessary to ensure safe surgery, history taking and physical examination should be performed to identify patients in whom the risk for cardiovascular complications is high, and diagnosis and evaluation should then be performed. Physicians should at this point also consider the long-term risk of cardiovascular disease as well. In general, the risk for cardiovascular complications is high among patients with a marked decrease in exercise capacity (≤5 metabolic equivalents [METs]), and careful evaluation of such patients is often necessary.

2.1 Risk Assessment for Cardiac Complications

The risk of cardiac complications during noncardiac surgery should be assessed on the basis of the type of noncardiac surgery (Table 1) and severity of underlying cardiac disorders. Patients with an active cardiac condition (Table 2) should be considered to receive treatment for the cardiac condition before noncardiac surgery when they are going to undergo non-urgent noncardiac surgery. Those without it should be considered to undergo noncardiac surgery first. The Revised Cardiac Risk Index (RCRI), a scoring system using 6 factors to predict the risk of cardiovascular complications and cardiovascular death, is useful to assess the risk of cardiac complications in patients undergoing noncardiac surgery (Table 3).

2.2 Preoperative Evaluation

In principle, preoperative cardiovascular evaluation should be performed using noninvasive techniques. However, Holter ECG and echocardiography are not useful in evaluating the risk of perioperative myocardial infarction (PMI). Appropriate techniques must be used, even if they are invasive. Since the incidence of serious complications of invasive examinations such as cardiac catheterization and cervical angiography is about 1%, such examinations should be reserved for patients in whom the results of examination will significantly contribute to the improve-

### Table 1. Cardiac Risk Stratification for Noncardiac Surgical Procedures Based on the Risk of Cardiac Complications

<table>
<thead>
<tr>
<th>Low (&lt;1%)</th>
<th>Intermediate (1% to 5%)</th>
<th>High (&gt;5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast surgery</td>
<td>Intraprostatic surgery</td>
<td>Aortic and other major vascular surgery</td>
</tr>
<tr>
<td>Dental surgery</td>
<td>Carotid endarterectomy</td>
<td>Peripheral vascular surgery</td>
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<td>Endoscopic procedures</td>
<td>Peripheral arterioplasty</td>
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<tr>
<td>Ophthalmic surgery</td>
<td>Endovascular aneurysm repair</td>
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<tr>
<td>Gynecological surgery</td>
<td>Head and neck surgery</td>
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<tr>
<td>Reconstructive surgery (plastic surgery)</td>
<td>Neurosurgery/major orthopedic surgery (hip joints or spine)</td>
<td></td>
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<tr>
<td>Minor orthopedic surgery (knee surgery)</td>
<td>Lung, kidney, or liver transplantation</td>
<td></td>
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<tr>
<td>Minor urological surgery</td>
<td>Major urological surgery</td>
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</tbody>
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Recommendations for Coronary Angiography in Patients Undergoing Noncardiac Surgery

**Class I**
- Evidence for high risk of adverse outcome based on noninvasive test results
- Angina unresponsive to adequate medical therapy
- Unstable angina
- Equivocal noninvasive test results in patients at high clinical risk and undergoing high-risk surgery

**Class III**
- Low-risk noncardiac surgery with known coronary artery disease and no high-risk results on noninvasive testing
- For screening of patients not undergoing appropriate noninvasive testing
- Asymptomatic after coronary revascularization with excellent exercise capacity
- Mild stable angina with good left ventricular function and no high-risk noninvasive test results
- Noncandidate for coronary revascularization owing to concomitant medical illness, or severe left ventricular dysfunction
- Undergoing adequate coronary angiography within 5 years
- Refusal to consider coronary revascularization

However, recent advancements in technology, including those in coronary angiography, have changed the process of diagnosis of cardiovascular conditions. There is little pathological significance to a slight increase in cardiothoracic ratio, or a single extrasystole, atrial fibrillation, or first-degree atrioventricular block in patients with good exercise capacity. Unnecessary examinations should be avoided. The plasma level of brain natriuretic peptide (BNP) correlates well with the severity of heart failure, and is useful in predicting the occurrence of cardiac complications during perioperative and medium-term and long-term postoperative periods. Stress ECG and stress myocardial perfusion imaging, and other techniques commonly considered noninvasive, may cause death in patients with severe left main coronary artery stenosis or severe aortic stenosis in rare cases.

### 2.3 Perioperative Monitoring

**2.3.1 ECG**
ECG monitoring is best performed for patients with arrhythmia or coronary artery disease. Although perioperative myocardial infarction is a serious complication that may lead to an early or late death, angina is absent in many cases. ST-segment monitoring of more than one lead is recommended. It is preferable that ECG monitoring should be continued until preoperative drug regimens for cardiac complications have been completely resumed. ECG monitoring before, during, and immediately after surgery, and succeeding 2 days is a cost-effective strategy. Arrhythmias during the early postoperative period are often caused by factors other than problems of the heart. Since supraventricular arrhythmia often disappears spontaneously and heart rhythm returns to sinus rhythm after causal factors have been eliminated, cardioversion is not recommended as a routine procedure for patients with it.

**2.3.2 Blood Pressure**
Patients at risk for abrupt hemodynamic changes during noncardiac surgery should be continuously monitored for blood pressure using an arterial line. Although blood pressure, when used as a single measure, does not accurately reflect hemodynamic condition and cardiovascular events,
continuous blood pressure monitoring during a limited period of time is indicated for certain types of patients such as those at high risk of perioperative myocardial infarction.

2.3.3 Central Venous Line, Pulmonary Artery (Swan-Ganz) Catheter
A central venous line is inserted and placed in patients whom significant hemodynamic changes can occur during the perioperative period for inotropic support and rapid fluid administration. However, central venous pressure provides limited information about hemodynamic conditions. Monitoring using a pulmonary artery catheter may enable detailed evaluation of hemodynamics in high-risk patients, though there are problems associated with its insertion and placement. As the ACC/AHA guidelines and the ESC/ESA guidelines described in 2014, it is generally considered that the perioperative use of pulmonary artery catheters brings more demerits than merits. Perioperative use of pulmonary artery catheters is not recommended as a routine procedure (Class III).

2.3.4 Transesophageal Echocardiography
Transesophageal echocardiography should be considered for patients with myocardial ischemia, those with unstable hemodynamics, or those with a high risk for these conditions. The use of transesophageal echocardiography as a continuous monitor should be limited to intraoperative use.

3. Outline of General Management

3.1 Preoperative Management

3.1.1 Prevention of Cardiac Events
Although the most common strategy for improving cardiac condition before noncardiac surgery is drug treatment, preoperative intensive care or cardiac surgery may be performed before noncardiac surgery.

a. Hypertension
Untreated or poorly controlled hypertension (systolic pressure $\geq 180$ mmHg, and/or diastolic blood pressure $\geq 110$ mmHg) should be controlled prior to noncardiac surgery. It is also important to assess the patient for hypertensive damage to the brain, heart, kidney, blood vessels, and ocular fundus. If pheochromocytoma is suspected, non-cardiac surgery should be postponed to assess for and resect the tumor before the noncardiac surgery. Antihypertensive drugs should basically be administered until the day of surgery, and be resumed after surgery without delay.

b. Ischemic Heart Disease
Acute coronary syndrome, and stable angina with evidence of ischemia at an exercise intensity of 4 metabolic equivalents (METs) should be treated before conducting noncardiac surgery. The patient should be considered for the indications of drug therapy and/or revascularization. The type of revascularization procedure for this patient population should be considered similarly to the procedure selected for those with ischemic heart disease who are not going to undergo noncardiac surgery.

c. Perioperative Beta-Blocker Therapy
Beta blockers reduce myocardial oxygen consumption, but block the mechanism to maintain cardiac output in response to reduced intravascular volume. Beta blockers reduce the incidence rate of perioperative myocardial infarction (PMI), while they elevate the rates of severe hypotension and cerebral infarction. No consensus exists as to the risk or benefit of perioperative beta-blocker therapy. When beta blocker therapy is introduced before noncardiac surgery, the dose should be adjusted carefully. Patients who have been on beta blockers for a long period of time should continue beta blocker therapy during the perioperative period if hemodynamics allow, as abrupt interruption of treatment may stimulate sympathetic nerve activity. As the credibility of randomized clinical studies on the perioperative use of beta blockers that supported recommendations in the ACC/AHA guidelines in 2007 and the ESC/ESA guidelines in 2009 was questioned, these guidelines were revised in August 2014.

Recommendations for Perioperative Beta-Blocker Therapy in Patients Undergoing Noncardiac Surgery

<ACC/AHA Guidelines>$^{3}$

Class I
1. Continue beta blockers in patients who are on beta blockers chronically. [Level of Evidence: B]

Class IIa

Class IIb
1. In patients with intermediate- or high-risk perioperative tests, it may be reasonable to begin beta blockers. [Level of Evidence: C]
2. In patients with $\geq 3$ RCRI factors, it may be reasonable to begin beta blockers before surgery. [Level of Evidence: B]
3. Initiating beta blockers in the perioperative setting as an approach to reduce perioperative risk is of uncertain benefit in those with a long-term indication but no other RCRI risk factors. [Level of Evidence: B]
4. It may be reasonable to begin perioperative beta blockers long enough in advance to assess safety and tolerability, preferably $>1$ day before surgery. [Level of Evidence: B]

Class III
1. Beta-blocker therapy should not be started on the day of surgery. [Level of Evidence: B]

<ESC/ESA Guidelines>$^{4}$

Class I
1. Perioperative continuation of beta blockers is recommended in patients currently receiving this medication. [Level of Evidence: B]

Class IIb
1. Preoperative initiation of beta blockers may be considered in patients scheduled for high-risk surgery and who have $\geq 2$ clinical risk factors or American Society of Anesthesiologists (ASA) status $\geq 3$. [Level of Evidence: B]
2. Preoperative initiation of beta blockers may be considered in patients who have known ischemic heart disease (IHD) or myocardial ischemia. [Level of Evidence: B]
3. When oral beta blockade is initiated in patients who undergo noncardiac surgery, the use of atenolol or bisoprolol as a first choice may be considered. [Level of Evidence: B]
Class III
1. Initiation of perioperative high-dose beta blockers without titration is not recommended. [Level of Evidence: B]
2. Preoperative initiation of beta blockers is not recommended in patients scheduled for low-risk surgery. [Level of Evidence: B]

Level B, Data derived from a single randomized trial or large-scale, non-randomized studies; Level C, Only consensus opinion of experts or small-size clinical studies (including retrospective studies and registries).

(Adapted from Kristensen SD, et al. Eur Heart J 2014; 35: 2383–2431, with permission from European Society of Cardiology)

3.1.2 Management of Antithrombotic Therapy

a. Antiplatelet Drugs
(i) Aspirin
No consensus exists on whether aspirin should be discontinued before surgery or not. It has been suggested that aspirin should be discontinued for 7 to 14 days before major surgery, including superficial surgery with difficulty in controlling bleeding during surgery, and that aspirin should be discontinued only in patients where the risk of bleeding complications outweighs the risk of cardiovascular events.

(ii) Thienopyridines (Ticlopidine, Clopidogrel)
It is recommended that clopidogrel should be discontinued 5 to 7 days before surgery, and ticlopidine 10 to 14 days before surgery.

(iii) Antiplatelet Therapy for Ischemic Heart Disease
Although it depends on the severity of intraoperative bleeding during noncardiac surgery, it is desirable that patients with ischemic heart disease who are taking aspirin continue aspirin therapy before and after noncardiac surgery. As patients who received drug-eluting stents (DES) are taking more than one antiplatelet drug, and the risk of in-stent thromboembolism increases substantially when they discontinue antiplatelet therapy, they are recommended not to undergo major surgery with the risk of bleeding for 1 year after DES placement (however, it has been reported that the risk of in-stent thromboembolism differs by type of DES).

b. Anticoagulants
(i) Vitamin K Blockers
When patients on anticoagulant therapy such as those after mechanical valve replacement are at a risk of serious complications due to discontinuation of anticoagulants before noncardiac surgery, they should be switched to heparin before surgery. Specifically, warfarin should be discontinued 3 to 5 days before surgery, and intravenous or subcutaneous heparin therapy should be initiated at a dose of 10,000 to 25,000 units/day. In high-risk patients, the heparin dose should be adjusted to achieve an activated partial thromboplastin time (aPTT) of 1.5 to 2.5 times the normal control value. Heparin should be discontinued 4 to 6 hours before surgery, or should be neutralized with protamine sulfate immediately before surgery. In either case, aPTT should be measured immediately before surgery. After surgery, heparin should be restarted without delay. After the patient’s condition has stabilized, warfarin should be restarted. Heparin should be discontinued when prothrombin time international normalized ratio (PT-INR) reaches the therapeutic range.

(ii) Direct Thrombin Inhibitors and Xa Inhibitors
These novel oral anticoagulants that are indicated for the treatment of non-valvular atrial fibrillation differ substantially in terms of pharmacokinetics, while no studies have been conducted to provide evidence on the effect of discontinuing drug therapy on patients undergoing noncardiac surgery.

3.2 Management of Anesthesia and Peri- and Postoperative Management

3.2.1 Selection of the Methods and Agents of Anesthesia
There are no particular anesthetic methods that yield significant myocardial protection during surgery. The most important prognostic factors are complications and surgical techniques. As volatile anesthetics inhibit cardiac contraction and reduce afterload, these agents should be used carefully for patients with cardiac diseases. Narcotic anesthetics have a stable effect on the cardiovascular system but may inhibit the respiratory system. Recently, intravenous propofol anesthesia has been established as a useful procedure. However, long-term, high-dose administration of propofol is contraindicated for children. Mask anesthesia, when performed by experienced anesthesiologists, is often safer than local anesthesia, during which respiratory and circulatory management is often difficult. Local anesthesia in combinations of intravenous anesthetics or analgesics had been considered safe in the past, but a recent analysis has reported that 30-day mortality is higher in patients anesthetized with this technique. Only limited patients are indicated for epidural or spinal anesthesia when they are using anticoagulants or have poor cardiac function. However, ultrasound guided nerve block may be performed for patients on anticoagulants, and is safer and produces a more consistent analgesic effect than other procedures.

3.2.2 Perioperative Pain Control
Most cardiac events in patients undergoing noncardiac surgery occur during the postoperative period. In facilitating early ambulation, normalizing blood coagulation, and preventing postoperative pulmonary embolism, adequate postoperative pain control is quite important. Patient-controlled analgesia (PCA) is a method with high patient satisfaction, and pain scores achieved with PCA are lower than with other analgesic methods. For example, epidural or spinal anesthesia with narcotics is beneficial in many respects, and physicians should consider use of this method when it is possible.

3.2.3 Perioperative Nitroglycerin
Perioperative nitroglycerin therapy may be beneficial in high-risk patients with signs of myocardial ischemia without hypotension who have received nitroglycerin, but is contraindicated for patients with hypovolemia or signs of hypotension.

3.2.4 Maintenance of Body Temperature During Surgery
Hypothermia during surgery is an obvious risk factor for perioperative cardiac events in patients at risk for heart disease. Active warming to maintain body temperature is recommended.
3.2.5 Intraaortic Balloon Pumping
The use of intra-aortic balloon pumping (IABP) for the prevention of surgical complications is not recommended for patients with unstable angina or severe coronary artery disease who are going to undergo noncardiac surgery.

3.2.6 Blood Glucose Control
Although the benefit of tight blood glucose control at 90 to 100 mg/dL in the critical care setting had been emphasized, there is no consensus on the benefit of tight blood glucose control in patients with cardiovascular disorders who are going to undergo noncardiac surgery. Recently, the risk of hypoglycemia is considered to outweigh the benefits of tight blood glucose control. Guidelines in Western countries recommend milder blood glucose control at around 180 mg/dL.

3.2.7 Venous Thromboembolism
The use of compression elastic stockings, low-dose heparin, low-molecular-weight heparin, warfarin, and/or intermittent pneumatic compression, among other measures to prevent venous thromboembolism during the perioperative period of noncardiac surgery are recommended for elderly patients, bedridden patients, those with paralysis, those with a history of thromboembolism, those with malignant tumor, those undergoing abdominal/pelvic/lower limb surgery, obesity patients, those with varicose vein, those with chronic heart failure, those with pelvic/femoral fracture, those with coagulation disorder, those receiving high-dose estrogen, and other high-risk patients.

3.2.8 Prevention of Infective Endocarditis
When fever of unknown origin develops in a patient implanted with mechanical valves or devices, the patient should be assessed for the cause, and receive with preventive antimicrobial therapy, considering the possibility of infective endocarditis.

4. Prevention of Cardiac Complications During Emergency Surgery

Patients who require emergency surgery often have conditions that may affect the heart, such as anemia and hypovolemia. Physicians must often start emergency surgery without appropriate evaluation of the risk of surgery and obtaining information on previous treatment of heart disease. In this situation, patients are likely to develop complications including cardiac complications. Physicians must pay special attention to possible ischemic heart disease, since emergency surgery is often initiated without performing coronary angiography, namely, the only method for its definitive evaluation.

4.1 Preoperative Management
Especially in patients with trauma, it is often difficult to obtain sufficient information before emergency surgery. It is preferable that physicians be aware of the possibility of heart disease. Physicians should assess the presence/absence of known risk factors for heart disease whenever possible. When arteriosclerotic lesions or other findings known to be associated with heart disease are present, physicians should assume that the patient has heart disease and manage them as such. A history of “asthma” is a word of caution, and may in fact represent heart failure.

Physicians should carefully examine the ECG for findings suggestive of myocardial ischemia, and consider coronary artery disease a possible cause of ventricular extrasystole, bradycardia, and/or blocks. When left ventricular hypertrophy is present, the presence of aortic stenosis or cardiomyopathy should be suspected.

Chest X-ray should be carefully evaluated for cardiomegaly, pulmonary congestion, and aortic calcification. It is quite important to improve the general condition before surgery. Anemia, hypovolemia, poor oxygenation, and peripheral hypoperfusion must be treated to the extent possible.

4.2 Intraoperative Management
The ECG is often the only continuous monitor available during surgery. Since bleeding and evaporation may exacerbate hypovolemia and anemia, patients should be carefully monitored for myocardial ischemia. When ST change, hypotension, or frequent arrhythmia occurs, hemodynamics and cardiac function should be evaluated using the ECG and transesophageal echocardiography, and appropriate treatment should be given. When heart failure or arrhythmia occurs, it is essential to control water balance, electrolyte balance, and anemia, if present. Since the incidence of ventricular fibrillation increases when the body temperature is 34°C or lower, hypothermia should be prevented.

Patients are especially prone to develop hypothermia during surgery with large-volume transfusion and/or rapid fluid administration and extensive surgery. It should be noted that rapid transfusion may cause hypocalcemia.

4.3 Postoperative Management
Appropriate postoperative management including adjustment of fluid volume is important to prevent cardiac over-load, especially in critically ill patients. Postoperative hyperglycemia may cause osmotic diuresis and consequent dehydration. Following emergency surgery, water and electrolyte balance are prone to be out of order. If hypokalemia is present, patients are more prone to develop atrial fibrillation and ventricular extrasystole.

Prolonged bed rest after emergency surgery may induce venous thrombosis and pulmonary embolism. If a venous line was placed in the femoral vein or leg vein before surgery, it should be changed to a new position in the upper extremities after the patient’s condition has stabilized.

4.4 Injuries to the Heart or Thoracic Great Vessels Associated With Multiple Trauma
Thoracic aorta injury accounts for many deaths after blunt trauma, although their frequency among total cases is not high. Thoracic aorta injury often occurs in the ascending aorta and the proximal descending aorta. Since patients with ascending aorta injury often fall into catastrophic condition rapidly, physicians treat patients mainly with injuries of the proximal descending aorta. When chest X-ray reveals a widened mediastinum and a large volume of pleural effusion or when echocardiography reveals pericardial effusion, CT and transesophageal echocardiography should be performed to exclude aortic injury prior to noncardiac surgery.

Priority of treatment in patients with multiple trauma
depends on individual cases.44,45 When the aorta is repaired first, blood loss during extracorporeal circulation will be a concern, while if noncardiac surgery is performed first, perioperative aortic rupture may develop. When aortic injury is managed conservatively, the patient should be carefully evaluated to find out conditions requiring aggressive surgical treatment. CT is the most useful method for objective evaluation in such circumstances.

## 5. Pregnancy/Delivery and Heart Disease

### 5.1 Pregnancy and Delivery in Patients With Congenital Heart Disease

Pregnancy and delivery pose no serious threats in women who had undergone corrective surgery for simple heart malformation or tetralogy of Fallot and have New York Heart Association (NYHA) Class II or better cardiac function.46 However, women should be carefully evaluated for remaining defects, since heart failure and/or arrhythmia may develop and cyanosis may be exacerbated during pregnancy and delivery.47,48 Table 4 outlines the safety of pregnancy and delivery for women with uncorrected congenital heart disease.

Although cases of pregnancy and delivery in women with cyanotic complex cardiac anomalies such as complete transposition of the great arteries, tricuspid atresia, and univentricular heart who have or have not undergone corrective surgeries have been reported,49-50 the risk of death and complications including fetus associated with pregnancy is quite high in this population. Live birth is rare among women with an arterial oxygen saturation ≤85%.51 Among women with complete transposition of the great arteries who have undergone the atrial switch operation, special care should be taken for those with a decrease in function of the anatomical right ventricle, those complicated with atroventricular valve regurgitation, and those complicated with sinus dysfunction. Data are limited on pregnancy and delivery in women following the Fontan procedure.

In women with Ebstein’s malformation, the type and incidence of complications such as right heart failure, paradoxical embolism, and infectious endocarditis depend on the severity of tricuspid insufficiency, presence/absence of existing right heart failure, and severity of cyanosis52 of complications of pregnancy and delivery.53 a number of successful pregnancies and deliveries in women with Ebstein’s malformation have been reported.54

### 5.2 Pregnancy and Delivery in Women With Valvular Disease

Pregnant women with mild or moderate mitral stenosis may receive diuretics and beta blockers to prevent and treat congestive heart failure and tachycardia, respectively.55 Diuretics should be used carefully, since excessive use of them may cause hypovolemia and result in suboptimal uteroplacental circulation.49,56 Percutaneous mitral valvuloplasty may be indicated for severe mitral stenosis before pregnancy. When heart failure not responding to medical therapy develops during pregnancy, physicians should consider percutaneous mitral valvuloplasty.49 Pregnancy and delivery in women with acquired aortic stenosis should be treated similarly to that in those with congenital aortic stenosis. Mitral insufficiency and aortic insufficiency may

| Table 4. Pregnancy and Delivery in Patients With Uncorrected Congenital Heart Disease |
|---------------------------------|---------------------------------|
| Atrial septal defect | No problem in most cases |
| Ventricular septal defect | No problem in most cases |
| Patent ductus arteriosus | No problem in most cases |
| Congenital aortic stenosis | Pressure gradient of ≤50mmHg (No problem if ≤25mmHg) |
| Coarctation of the aorta | Pressure gradient of 20 to ≤30mmHg, asymptomatic |
| Pulmonary artery stenosis | Pressure gradient of ≤80mmHg |
| Tetralogy of Fallot | Pregnancy and delivery are dangerous if hematocrit is ≥60%; arterial oxygen saturation is ≤80%; or increased right ventricular pressure had developed or syncope has occurred. |
| Cyanotic complex cardiac anomalies | No consensus |
| Eisenmenger syndrome | Contraindicated |
| Marfan syndrome | No expansion of the ascending aorta |

| Table 5. Recommendations for Anticoagulation Therapy During Pregnancy in Patients With Mechanical Prosthetic Valves |
|------------------------------------------|------------------------------------------|
| **Weeks 1 through 35** |
| **Class I** |
| 1. The decision whether to use heparin during the first trimester or to continue oral anticoagulation throughout pregnancy should be made after full discussion with the patient and her partner; if she chooses to change to heparin for the first trimester, she should be made aware that heparin is less safe for her, with a higher risk of both thrombosis and bleeding, and that any risk to the mother also jeopardizes the baby.58 |
| 2. High-risk women (a history of thromboembolism or an older-generation mechanical prosthesis in the mitral position) who choose not to take warfarin during the first trimester should receive continuous unfractionated heparin intravenously in a dose to prolong the mid-interval (6 hours after dosing) aPTT to 2 to 3 times control. Transition to warfarin can occur thereafter. |
| **Class IIa** |
| 1. In patients receiving warfarin, INR should be maintained between 2.0 and 3.0 with the lowest possible dose of warfarin, and low-dose aspirin should be added. Class IIb |
| **Class IIb** |
| 1. Women at low risk (no history of thromboembolism, newer low-profile prosthesis) may be managed with adjusted-dose subcutaneous heparin (17,500 to 20,000 U BID) to prolong the mid-interval (6 hours after dosing) aPTT to 2 to 3 times control. |

After the 36th week

| **Class IIa** |
| 1. Warfarin should be stopped no later than week 36 and heparin substituted in anticipation of labor. |
| 2. If labor begins during treatment with warfarin, a Caesarian section should be performed. |
| 3. In the absence of significant bleeding, heparin can be resumed 4 to 6 hours after delivery and warfarin begun orally. |

aPTT, activated partial thromboplastin time; INR, international normalized ratio; U, unit; BID, twice a day. (Adapted from ACC/AHA guidelines for the management of patients with valvular heart disease, J Am Coll Cardiol 1998; 32: 1486–1588, with permission from Elsevier. [http://www.sciencedirect.com/science/article/pii/S0735109798004549])
Preoperative myocardial infarction (PMI) may develop when perioperative stress causes increases in blood pressure and heart rate, resulting in acute coronary occlusion or prolonged imbalance between myocardial oxygen demand and supply. As acute coronary occlusion is often caused by the rupture of a non-hemodynamically significant atherosclerotic plaque, patients often show no significant symptoms of ischemic heart disease before surgery, and do not exhibit abnormal findings even when a detailed coronary assessment is performed. Imbalance between myocardial oxygen demand and supply is often observed in patients with chronic myocardial ischemia.

### 1.1 Prevention of PMI

Patients with unstable angina and hemodynamically significant coronary lesions should be treated for the heart condition before noncardiac surgery, in principle. Patients with stable angina and hemodynamically significant coronary lesions may undergo low-risk noncardiac surgery first in many cases. However, those who are going to undergo intermediate- or high-risk noncardiac surgery and are indicated for cardiac revascularization should be considered for revascularization before noncardiac surgery. Procedures of revascularization should be the same for patients who receive revascularization only.

The ACC/AHA guidelines and the ESC/ESA guidelines were revised in August 2014 as the credibility of randomized clinical studies on the perioperative use of beta blockers, which provided evidence for recommendations in these guidelines, was questioned.

### Recommendations for Coronary Revascularization Before Noncardiac Surgery

**Class I**

- Patients with unstable angina
- Patients with stable angina, and left main coronary artery disease, severe triple-vessel disease, or Double-vessel disease affecting the proximal left anterograde...
rior descending artery, and low left ventricular ejection fraction (or poor cardiac function)

Class III
- Patients with stable angina who are going to undergo low-risk noncardiac surgery

Patients who underwent coronary artery bypass grafting (CABG) in the past 5 years may undergo noncardiac surgery relatively safely when their clinical symptoms are stable. Those receiving aspirin should continue aspirin therapy during endoscopic procedures. Table 7 lists recommendations for anticoagulant therapy for patients using coronary stents especially drug-eluting stents (DES). They are at a risk of acute coronary occlusion even if they do not have hemodynamically-significant coronary lesions, but its occurrence during the perioperative period of noncardiac surgery cannot be predicted. Patients with severe atherosclerosis should receive careful perioperative management considering their risk of PMI to ensure sufficient postoperative pain control, which is important to prevent reactive coronary spasm, maintain stable blood pressure using antihypertensive drugs, treat tachycardia, and stabilize plaques using statins. Patients with evidence of coronary spasm should be treated with calcium channel blockers, but excessive antihypertensive therapy should be avoided.

Recommendations for Aspirin Therapy During the Perioperative Period of Noncardiac Surgery

Class IIa
- Continuation of aspirin therapy during the perioperative period of noncardiac surgery in patients already receiving aspirin

Recommendations for Statin Therapy During the Perioperative Period of Noncardiac Surgery

Class I
- Continuation of statin therapy during the perioperative period of noncardiac surgery in patients already receiving statins
- Initiation of statin therapy before high-risk noncardiac surgery

1.2 Diagnosis of PMI

Most PMIs start within 48 hours of surgery. Many patients do not complain of typical chest pain. Only about 10% of patients show typical ST elevation on ECG and ST depression is a common ECG finding. Continuous 12-lead ECG monitoring and measurement of myocardial biomarkers (e.g., serum creatinine kinase-MB isoenzyme and myocardial troponin) provide useful information.

1.3 Treatment of PMI

Cardiologists specialized in the medical treatment of ischemic heart disease should support the treatment of perioperative PMI. Treatment with oral aspirin, heparin infusion, or treatment with nitrates should be considered, and arrhythmias, if present, should be managed appropriately. If pump dysfunction develops in the acute phase of PMI, circulatory support with IABP should be considered.

Emergency percutaneous coronary intervention (PCI) may be effective for the treatment of acute coronary occlusion, while CABG may be indicated for only limited patients with PMI due to an imbalance between myocardial demand and supply considering their risks comprehensively.

2. Valvular Heart Disease

When cardiac murmur is heard prior to noncardiac surgery, physicians must identify the cause of the murmur, consider whether the murmur reflects a serious condition or not, whether further assessment is needed to investigate its severity, and whether prevention of infectious endocarditis is required. Diastolic murmurs are almost always pathologically significant, and diagnosis and investigation of them is required. Diastolic murmurs are almost always pathologically significant, and diagnosis and investigation of them is required. It is quite rare for functional murmurs with a grade ≥ III to IV on the Levine scale to be heard, but the loudness of murmurs depends on body size and does not accurately reflect the severity of valvular disease.

2.1 Valvular Diseases and Noncardiac Surgery

2.1.1 Aortic Stenosis

Severe aortic stenosis is one of the most important risk factors for cardiac complications during noncardiac sur-

Table 7. Recommendations Regarding PCI and Patient Management Prior to Noncardiac Surgery

1. Dual antiplatelet therapy using aspirin and thienopyridine (ticlopidine or clopidogrel) is the most beneficial regimen for preventing in-stent thrombosis. It is recommended that, following stenting, especially using drug-eluting stents (DES), patients undergo dual antiplatelet therapy for 12 months. Early discontinuation of this regimen significantly increases the risks of in-stent thrombosis, myocardial infarction, and death.

2. Physicians should be aware that dual antiplatelet therapy is required after stenting, and consider avoidance of DES implantation in patients who cannot complete 12-months thienopyridine therapy. Physicians should well consider whether to use DES or not in patients who have or are suspected to have malignant disease.

3. For patients who are to undergo PCI and who may require invasive procedures or surgery within 12 months after PCI, physicians should consider the use of bare metal stents or balloon angioplasty rather than DES implantation.

4. Physicians should fully explain to patients the importance of antiplatelet therapy with thienopyridine, and instruct them to consult a physician when they need to discontinue antiplatelet therapy.

5. When invasive procedures are performed in patients with stents on antiplatelet therapy, physicians should be aware that early discontinuation of antiplatelet therapy after stenting may have serious complications, and should carefully discuss with cardiologists over the optimal treatment strategy.

6. It is preferable that elective surgery with a high risk of bleeding during and after surgery be avoided during the 12-month period after implantation of DES and at least one month after implantation of bare metal stents.

7. When patients with DES must discontinue thienopyridine therapy for surgical procedures, they should continue aspirin therapy whenever possible, and should resume thienopyridine therapy promptly after surgery. When all antiplatelet agents must be discontinued, it is preferable that patients be treated with heparin.*

*However, there is no evidence of prevention of in-stent thrombosis by heparin therapy in patients receiving DES or bare metal stents, and heparin therapy is empirically conducted in many institutions in Japan. PCI, percutaneous coronary intervention; DES, drug-eluting stents. (Adapted from Grines CL, et al. Circulation 2007; 115: 813–818.44)
It is preferable that noncardiac surgery be avoided or aortic valve replacement be performed prior to noncardiac surgery in patients with symptomatic aortic stenosis with a left ventricular-aortic pressure gradient of ≥50 mmHg, syncope, anginal pain, and/or left heart failure (Figure 1). The safety of transcatheter aortic valve implantation (TAVI) and transcatheter aortic valve replacement (TAVR) has advanced recently, and these techniques are increasingly considered as effective options for patients for whom conventional valve replacement is difficult.

### 2.1.2 Mitral Insufficiency

No specific measures are required during noncardiac surgery in patients with mild or moderate mitral regurgitation and without signs/symptoms of heart failure. However, antibiotic prophylaxis is needed to prevent infectious endocarditis. Mitral valve surgery such as valvuloplasty and prosthetic valve replacement should be performed first in patients with moderate or severe mitral regurgitation and signs/symptoms of heart failure. It should be noted that mitral insufficiency often causes a seemingly favorable left ventricular ejection fraction. Perioperative antibiotic therapy is required to prevent infections not only in patients with clinically significant mitral valve prolapse but also in asymptomatic patients in whom echocardiography reveals findings of mitral regurgitation or thickened valve leaflets.

### 2.1.3 Tricuspid Insufficiency

Since patients with severe tricuspid insufficiency may exhibit significant hepatic congestion possibly resulting in hepatic disorders such as hepatic cirrhosis, modification of treatment strategies is often required if high-risk noncardiac surgery is to be performed.

### 2.1.4 Aortic Insufficiency

In patients with aortic regurgitation of grade II or less, noncardiac surgery may be performed before cardiac surgery when appropriate measures including the prevention of infectious endocarditis are taken. In patients with aortic regurgitation of grade III or higher and those with clinical symptoms, physicians should be aware that the risk of noncardiac surgery is, depending on the type of surgery performed, often significantly high when performed prior to surgical treatment of aortic regurgitation. Fatal arrhythmia may often occur in this patient population, and perioperative management is difficult. Although the risk of noncardiac surgery varies according to the type of procedure, it is preferable that surgical treatment of aortic valves be performed first before left heart function has significantly exacerbated.

### 2.1.5 Mitral Stenosis

Most noncardiac surgical procedures may be performed in patients with mitral stenosis with a systolic pulmonary artery pressure of ≤50 mmHg or a valve orifice area of ≥1.5 cm². However, heart rate should be controlled during the perioperative period, since tachycardia may induce serious pulmonary congestion. It is preferable that patients with severe mitral stenosis undergo percutaneous transcatheter balloon mitral commissurotomy, or surgical commissurotomy or mitral valve replacement before undergoing high-risk noncardiac surgery.

### 2.1.6 After Prosthetic Valve Replacement

In order to prevent infectious endocarditis during the perioperative period, antibiotics should be administered to patients with prosthetic valves from the day before noncardiac surgery.
The prevalence of heart disease in neonates is 13.2 to 43% among those with esophageal atresia, 88–93 9 to 12.1% among those with anal atresia, 88 13.9 to 45.5% in those with exomphalos, 88,92–95 17.9 to 33% in those with duodenal atresia, 88,92–95 and 14 to 25% in those with diaphragmatic hernia. 96 Children born with conditions requiring surgical treatment immediately after birth should be evaluated with echocardiography.

Although the methods of surgical correction of anal atresia and intestinal atresia/stenosis are well established, the mortality rates of neonates and infants with large exomphalos and diaphragmatic hernia are still high. In such infants, it is quite difficult to perform surgical correction of heart disease during early infancy. 94 In children with esophageal atresia and heart disease, correction of esophageal atresia is often performed first. However, no consensus has been reached regarding the timing of heart surgery (before or after correction of esophageal atresia) or the strategy of treatment for esophageal atresia (one- or two-stage corrective surgery).

In neonates with congenital heart diseases that increase pulmonary blood flow, surgical correction of noncardiac disease may be performed during the first several days of life, during the period when pulmonary vascular resistance remains high, while in neonates with congenital heart diseases that decrease pulmonary blood flow, noncardiac surgery may be performed when cyanosis has improved by treatment with prostaglandin (PG) E1 (0.05 to 0.1 mcg/kg/min) to a stable hemodynamic condition. No consensus exists regarding treatment strategy or the order of cardiac and noncardiac surgeries in patients with complex heart disease who exhibit cyanosis and increased pulmonary blood flow.

Many types of congenital heart diseases can be diagnosed with echocardiography, and cardiac catheterization and/or angiography is rarely required.

### 3.2 Young Children

Baum et al reported that, in children ≥1 year of age, the mortality after noncardiac surgery was slightly higher in those with cardiac disease, though the difference was not significant. 87 Pulmonary hypertension (PH) and severe cyanosis and so on are considered as risk factors for mortality after noncardiac surgery, though no evidence has been obtained for this. Clinical experience has suggested that children following palliative surgeries such as shunt surgery and the Glenn procedure can tolerate noncardiac surgery well. When anesthetic procedures requiring mechanical ventilation are performed, prompt extubation may be preferable for ensuring favorable hemodynamics.

### 4. Adults With Congenital Heart Disease

#### 4.1 Cardiovascular Evaluation Prior to Noncardiac Surgery

Patients with congenital heart disease planned to undergo noncardiac surgery should be evaluated for history of cardiac surgery and the procedures used, presence/absence and type of persistent heart lesions, complications and sequelae of heart disease, clinical course after heart surgery, and current condition. In patients planned to undergo low-risk noncardiac surgery as defined in the ACC/AHA Guidelines, routine preoperative evaluation is sufficient. 5,6 When high- or intermediate-risk noncardiac surgery is planned,
patients should be evaluated for cardiovascular abnormality in detail. If the results are poor, cardiac surgery or catheter intervention prior to noncardiac surgery may be considered.

4.2 Cardiac Risk Factors During the Perioperative Periods.97

Table 8 lists common risk factors in adult patients with congenital heart disease:

4.3 Examinations Used in Preoperative Evaluation of Risk Factors

All patients with congenital heart disease require preoperative evaluation with 12-lead ECG, chest X-ray, and echocardiography. While arterial blood gas analysis, pulmonary ventilation/perfusion scintigraphy, and Holter ECG may be necessary in some cases, exercise stress testing and cardiac catheterization are indicated for only a small number of patients.

4.4 Problems Following Corrective Surgery

Following corrective surgery for acyanotic congenital heart disease, patients may experience embolism secondary to atrial arrhythmia/fibrillation; congestive heart failure due to a residual shunt; severe PH; mitral insufficiency/stenosis or left ventricular outflow obstruction following correction of atrioventricular septal defect; and restenosis of repaired aortic coarctation, among other conditions.

Patients born with cyanotic complex cardiac anomaly may often require reoperation at a later age even if they are treated with corrective surgery. Depending on the procedure of the corrective surgery, patients may exhibit characteristic hemodynamic changes for which special management may be needed during noncardiac surgery. Patients with the conditions listed in Table 8,97 valvar regurgitation, or serious arrhythmia must be treated especially carefully. Patients with following conditions need special care: for patients after atrial switch operation, vena cava obstruction, pulmonary venous stenosis, right ventricular dysfunction which acts as systemic ventricle. For patients after atrial switch operation, pulmonary artery stenosis. Patients who had undergone Fontan operation are prone to heart failure. About 10 years after the Fontan operation, patients are prone to develop supraventricular arrhythmias, thromboembolism, protein-losing gastroenteropathy, hepatic congestion, hepatic dysfunction, decrease in cardiac function, or other abnormal conditions, and thus require careful management.

4.5 Problems With Uncorrected Congenital Heart Disease

No special perioperative management is required for noncardiac surgery in patients with congenital heart disease not indicated for surgery such as small atrial or ventricular septal defect and acyanotic tetralogy of Fallot. Many patients with large uncorrected left-to-right shunt exhibit Eisenmenger syndrome, and the risk of noncardiac surgery is quite high in these patients. Patients with cyanosis must be carefully managed for hypoxemia, polycythemia, prevention of visceral disorder, brain abscess, and infectious endocarditis.
4.6 Important Aspects of Perioperative Management

Perioperative management of patients with a history of congenital heart disease who are undergoing noncardiac surgery is performed mainly to prevent heart failure, hypoxemia, and arrhythmias. Selective pulmonary vasorelaxants are effective in patients with right ventricular failure. It is important to prevent infectious endocarditis (Table 9) and brain abscess in patients with cyanotic heart disease.

5. Aortic Diseases

5.1 Evaluation and Treatment Priorities of Aortic Aneurysm During Noncardiac Surgery

Tables 10 and 11 list considerations for patients with aortic aneurysm who are going to undergo noncardiac surgery. Patients with an abdominal aneurysm ≥6cm in diameter should undergo aortic aneurysm surgery first even though noncardiac surgery is planned for the treatment of malignant tumors. Patients who are going to undergo abdominal surgery should undergo aortic aneurysm surgery and abdominal surgery at the same time. Treatment of aortic aneurysm should be prioritized in patients with acute aortic dissection, symptomatic patients with ruptured (or rupturing) aortic aneurysm, and those with pseudoaneurysm, except cases where the noncardiac disease needs prompt treatment. Figure 2 illustrates a flow chart of treatment for patients complicated with noncardiac disease and abdominal/thoracic aortic aneurysm. However, priority of treatment depends on individual cases, and further research should be conducted. Patients with the following anatomical characteristics should be considered for the indication of thoracic endovascular aortic repair (TEVAR) or endovascular abdominal aortic aneurysm repair (EVAR). It is expected that EVAR may minimize the surgical invasion in simultaneous surgery for the treatment of abdominal aortic aneurysm and noncardiac disorder, and shorten the time lag from the treatment of aortic aneurysm and the noncardiac disorder in patients undergoing two-phase surgery. However, the preventive use of EVAR for patients who do not meet the criteria is not supported. There is no sufficient evidence to support the use of TEVAR. However, this technique is worth considering because early results are favorable and its surgical invasion is minimal.

5.2 Management of Aortic Aneurysm During the Perioperative Period of Noncardiac Surgery

During the perioperative period of noncardiac surgery, patients with aortic aneurysms should be carefully observed for ischemic heart disease and severe hypertension that frequently co-exist. Pain control is also important to ensure stable blood pressure. Although there have been few reports about aortic aneurysm rupture during the perioperative period of noncardiac surgery, perioperative blood pressure control has been reported to be effective in preventing the rupture of aortic aneurysms. When hypertension is mild or moderate and no abnormal findings related to hypertension are observed, noncardiac surgery may not be postponed. However, patients with severe hypertension require careful blood pressure control throughout the perioperative period. In patients who cannot take drugs orally and who are going to undergo emergency surgery, intravenous infusion of antihypertensives is recommended. After aortic aneurysm surgery, the patient should be assessed carefully to rule out abnormalities of the treated site (e.g., anastomotic false aneurysm and endoleak), and be treated appropriately to prevent bacteriemia and graft infection.

5.3 Rare Heart Diseases/Conditions

5.3.1 Aortitis Syndrome (Takayasu Disease)

Surgical treatment is required in 13% of patients with aortitis syndrome. To ensure the safety of noncardiac surgery, patients should be carefully observed for hypertension due to renal artery stenosis and heart failure associated with aortic regurgitation. Patients with active inflammation as suggested by a high CRP level should be treated with corticosteroids to control inflammation and corticosteroid therapy should be reduced before noncardiac surgery when it is not urgently required.

5.3.2 Marfan Syndrome

The outcome of cardiovascular surgery in patients with Marfan syndrome is excellent. When appropriate cardiovascular evaluation does not reveal abnormal findings, patients with Marfan syndrome may usually undergo conventional noncardiac surgery.

Table 10. Items for Assessment of Aortic Aneurysm

<table>
<thead>
<tr>
<th>1. Assessment of aortic aneurysm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximal diameter</td>
</tr>
<tr>
<td>Location/growth</td>
</tr>
<tr>
<td>Shape</td>
</tr>
<tr>
<td>Changes over time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Vascular assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence/absence of carotid artery lesions</td>
</tr>
<tr>
<td>Presence/absence of cerebrovascular disorder</td>
</tr>
<tr>
<td>Presence/absence of arteriosclerosis obliterans</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Systemic assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac function</td>
</tr>
<tr>
<td>Presence/absence of coronary artery disease</td>
</tr>
<tr>
<td>Respiratory function</td>
</tr>
<tr>
<td>Presence/absence of renal dysfunction</td>
</tr>
<tr>
<td>Assessment of hypertension</td>
</tr>
</tbody>
</table>

Table 11. Items for Assessment of Noncardiac Vascular Disorders

<table>
<thead>
<tr>
<th>1. Risk factors associated with acute-phase treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence/absence of bleeding, intestinal obstruction, and infection</td>
</tr>
<tr>
<td>Surgical procedure, posture, surgical field, duration of surgery, volume of bleeding, and cleanliness</td>
</tr>
<tr>
<td>Presence/absence of supportive treatment (radiotherapy/chemotherapy)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Assessment of long-term prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staging</td>
</tr>
<tr>
<td>Assumed life prognosis</td>
</tr>
</tbody>
</table>

JCS Guidelines for Perioperative Cardiovascular Evaluation and Management for Noncardiac Surgery
1. Priority of thoracic aortic aneurysm surgery and noncardiac surgery

<table>
<thead>
<tr>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruptured TAA</td>
<td>Malignant tumors (advanced cancer, cancer requiring highly invasive surgery)</td>
<td>Perform aortic surgery first or simultaneously</td>
</tr>
<tr>
<td>False aortic aneurysm (excluding those surrounded by significant adhesion)</td>
<td>Malignant tumors (advanced cancer, cancer requiring highly invasive surgery)</td>
<td>Simultaneous surgery</td>
</tr>
<tr>
<td>Type A acute aortic dissection with patent false lumen</td>
<td>Malignant tumors (advanced cancer, cancer requiring highly invasive surgery)</td>
<td>Perform aortic surgery later or simultaneously</td>
</tr>
<tr>
<td>Aortic dissection with severe complications which surgery may improve or prevent disease progression</td>
<td>Malignant tumors (advanced cancer, cancer requiring highly invasive surgery)</td>
<td>Perform aortic surgery first or simultaneously</td>
</tr>
</tbody>
</table>

Figure 2. Guidelines for priority of thoracic/abdominal aortic aneurysm surgery and noncardiac surgery.

2. Priority of abdominal aortic aneurysm surgery and noncardiac surgery

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal aortic aneurysm</td>
<td>Class I</td>
</tr>
<tr>
<td>Perform aortic surgery first (or simultaneously in some noncardiac diseases)</td>
<td>Ruptured aneurysm</td>
</tr>
<tr>
<td></td>
<td>Symptomatic aneurysm</td>
</tr>
</tbody>
</table>
| | Spindle-shaped aneurysm ≥6 cm of maximal diameter | Rapidly expanding aneurysm | AAA, abdominal aortic aneurysm; ASO, arteriosclerosis obliterans.

Table 12. Guidelines for Noncardiac Vascular Surgery in Patients Complicated With Peripheral Artery Disease

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracranial stenosis of carotid artery</td>
<td>Class I</td>
</tr>
<tr>
<td>Perform carotid surgery first (or simultaneously in some noncardiac diseases)</td>
<td>Symptomatic carotid stenosis ≥70%</td>
</tr>
<tr>
<td></td>
<td>Symptomatic carotid stenosis 50 to 69%</td>
</tr>
</tbody>
</table>

ASO of the lower extremities | Severe limb ischemia | Intermittent claudication |
5.4 Management of Aortic Aneurysms in Patients With Other Heart Diseases
5.4.1 Ischemic Heart Disease
It has been reported that coronary lesions are observed in one-eighth of patients with aortic dissection and one-third of patients with true aortic aneurysm. Ischemic heart disease is more common among patients with AAA. Hemodynamics during the perioperative period of aortic aneurysm are often unstable due to underlying hypertension and systemic arteriosclerosis, but IABP cannot be used in patients with aortic aneurysm. The presence or absence of coronary artery lesions significantly affects the treatment plans for patients undergoing aortic surgery.

Patients with aortic disease requiring elective, nonurgent surgery and symptomatic or severe coronary artery disease should undergo coronary surgery first, coronary surgery and aortic aneurysm surgery simultaneously, or coronary intervention first. DES, which require long-term treatment and aortic aneurysm surgery simultaneously, or coronary surgery and symptomatic or severe coronary artery disease plans for patients undergoing aortic surgery.

Patients with aortic disease requiring elective, nonurgent surgery and symptomatic or severe coronary artery disease should undergo coronary surgery first, coronary surgery and aortic aneurysm surgery simultaneously, or coronary intervention first. DES, which require long-term treatment and potent antiplatelet drugs, are not feasible in patients planned to undergo aortic aneurysm surgery after coronary stenting. When simultaneous surgery is selected, hybrid treatment, namely, off-pump coronary bypass surgery and transcatheter coronary intervention should be considered. Patients with aneurysms in the descending aorta or thoracoabdominal aorta may simultaneously undergo aortic surgery and bypass surgery to the left anterior descending artery and/or the circumflex coronary artery.

5.4.2 Valvular Heart Disease
When aortic surgery and valve surgery can be performed through the same incision, simultaneous surgery is feasible provided that cardiac function is normal. Although no consensus has been reached regarding the optimal surgical treatment of aortic lesions and valvular lesions which cannot be treated through the same incision, it is important to consider stent grafting as an option.

6. Peripheral Arterial Disease
Table 12 shows guidelines for evaluation and management of patients who have carotid artery stenosis or peripheral arterial disease of the lower extremities and are to undergo noncardiac surgery under general anesthesia (cases of emergency surgery for noncardiac diseases are excluded). Since peripheral arterial disease may develop as a result of arteriosclerosis, patients diagnosed with a vascular lesion must be examined for other vascular lesions.

6.1 Carotid Artery Stenosis
The carotid artery should be checked in patients with a history of cerebral infarction and those suspected to be experiencing a transient ischemic attack (TIA). Patients with carotid artery stenosis are at risk for cerebral infarction during the perioperative period of noncardiac surgery. Since the risk of cerebral infarction is high in males, patients with a history of cerebral infarction rather than TIA, and patients with cerebral hemisphere signs and symptoms rather than amaurosis, carotid surgery should be considered. No benefit of carotid surgery has been observed in patients with mild stenosis with or without symptoms. Carotid endovascular treatment may be considered in patients with symptomatic severe carotid artery stenosis, those in whom the surgical approach to the carotid artery is difficult, those with a high risks associated with surgery, those with carotid artery stenosis after radiotherapy, and those with carotid artery restenosis after surgery. When patients with carotid artery stenosis undergo noncardiac surgery without treating carotid artery stenosis, patients should be managed carefully to prevent dehydration and hypotension and thus prevent cerebral infarction.

Table 12. Updated Clinical Classification of Pulmonary Hypertension [a Draft Dana Point/Nice Classification]

<table>
<thead>
<tr>
<th>Group 1: Pulmonary arterial hypertension (PAH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Idiopathic PAH (IPAH)</td>
</tr>
<tr>
<td>2) Heritable PAH (HPAH)</td>
</tr>
<tr>
<td>3) Drug- and toxin-induced PAH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2: Pulmonary hypertension due to left heart diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Systolic dysfunction</td>
</tr>
<tr>
<td>2) Diastolic dysfunction</td>
</tr>
<tr>
<td>3) Valvular disease</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 3: Pulmonary hypertension due to lung diseases and/or hypoxia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Chronic obstructive pulmonary disease (COPD)</td>
</tr>
<tr>
<td>2) Interstitial lung disease (ILD)</td>
</tr>
<tr>
<td>3) Other pulmonary diseases with mixed restrictive and obstructive pattern</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 4: Chronic thromboembolic pulmonary hypertension (CTEPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Hematological disorders: chronic hemolytic anemia, myelo-proliferative disorders, splenectomy</td>
</tr>
<tr>
<td>2) Systemic disorders: sarcoidosis, pulmonary Langerhans cell histiocytosis, lymphangioleiomyomatosis, neurofibromatosis, vasculitis</td>
</tr>
<tr>
<td>3) Metabolic disorders: glycogen storage disease, Gaucher disease, thyroid disorders</td>
</tr>
<tr>
<td>4) Others: tumoral obstruction, fibrosing mediastinitis, chronic renal failure on dialysis</td>
</tr>
</tbody>
</table>

Segmental pulmonary hypertension

6.2 Atherosclerosis Obliterans of the Lower Extremities

Noncardiac surgery should be prioritized in patients with intermittent claudication, but patients in the perioperative period should be monitored carefully for the development of acute deterioration of blood flow in the lower extremities. Careful monitoring should be performed, particularly in patients with severe chronic leg ischemia whose blood pressure is \( \leq 50 \) to \( 70 \) mmHg in the foot joint and \( \leq 30 \) to \( 50 \) mmHg in the toes. When acute ASO of the lower extremities develops, amputation of the lower extremities may be required, or reperfusion injury followed by multi-organ failure may occur.

6.3 Management of Inferior Vena Cava Filters

Thrombosis in the inferior vena cava is not a rare condition. Whenever possible, patients who have been using an inferior vena cava (IVC) filter for a long period of time should continue anticoagulant therapy during the perioperative period. Patients in whom an IVC filter was placed recently should continue anticoagulant therapy whenever possible. After temporary IVC filter placement, patients should be carefully monitored for catheter infection, filter thrombosis (capture of thrombus), and catheter fracture. When a thrombus greater than \( 25\% \) of the filter volume is observed in angiography or contrast CT, urokinase should be administered through the filter at a dose of \( 240,000 \) to \( 480,000 \) units/day to debulk the thrombus before the removal of the filter. When the thrombus cannot be debulked, suctioning the thrombus or placing a permanent IVC filter should be considered.

7. Pulmonary Artery Disease

At the 4th World Symposium on Pulmonary Hypertension, which took place in Dana Point, California, in 2008, a new definition of pulmonary hypertension was proposed. The proposed new definition of pulmonary hypertension is a resting mean pulmonary arterial pressure (PAP) of \( \geq 25 \) mmHg, and the exercise and pulmonary vascular resistance criteria were eliminated. The Venice Clinical Classification of Pulmonary Hypertension was revised, and the Dana Point classification was published in 2008. A minor revision was made at the 5th World Symposium held in Nice, France, in 2013 (Table 13).

Diagnostic criteria for pulmonary hypertension are outlined in the following table.

<table>
<thead>
<tr>
<th>Clinical findings:</th>
<th>Exertional dyspnea, cyanosis, jugular venous distention, hepatomegaly, leg edema, ascites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auscultation:</td>
<td>Pulmonary diastolic murmur and apical holosystolic murmur</td>
</tr>
<tr>
<td>Chest X-ray:</td>
<td>Left second arc protrusion and decrease in peripheral vessel shadow, left fourth arc protrusion</td>
</tr>
<tr>
<td>ECG:</td>
<td>Right axis deviation, pulmonary P wave, right ventricular overload/hypertrophy</td>
</tr>
<tr>
<td>Echocardiography:</td>
<td>Right ventricular enlargement, paradoxical motion of the interventricular septum, increase in right ventricular pressure and/or pulmonary arterial pressure</td>
</tr>
</tbody>
</table>

Pulmonary artery disease is strongly suspected when resting mean pulmonary arterial pressure in catheterization is \( \geq 25 \) mmHg, and hypocapnia with hypoxemia are observed on arterial blood gas analysis, while no significant pulmonary parenchyma diseases or airway disorders are observed on respiratory function testing. Prior to noncardiac surgery, physicians should consider that the natural history of moderate or severe PH is quite poor.

No systematic criteria are available to evaluate the risk of perioperative complications in noncardiac surgery in patients with PH. Since patients with PH tend to have hypoxemia and right heart failure, careful monitoring (ECG, arterial line placement, and pulse oximetry) should be performed from the induction of anesthesia through the postoperative period. Although pulmonary arterial catheterization provides important information, it is difficult to place the catheter at an appropriate position, and lung injuries due to puncture and vessel injuries due to balloon dilatation may cause serious outcomes. Transesophageal echocardiography is very useful for monitoring the right ventricular function.

The effects of decreasing pulmonary vascular resistance during the perioperative period of noncardiac surgery with inhaled nitric oxide, dipyridamole, phosphodiesterase (PDE) III inhibitors, PG12, calcium blockers, and intravenous nitroglycerin have been reported. Endothelin-1 receptor antagonist are effective but not appropriate during the perioperative period, since only oral forms of them are available.

8. Idiopathic Cardiomyopathy

Cardiomyopathy is typically defined as “heart muscle disease associated with cardiac dysfunction” and is classified into dilated cardiomyopathy, hypertrophic cardiomyopathy, restrictive cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy, and other unclassifiable cardiomyopathy [Report of the 1995 World Health Organization/International Society and Federation of Cardiology Task Force on the Definition and Classification of Cardiomyopathies, 1995]. “Heart muscle disease with known etiology or clearly related to systemic disease” is defined as specific cardiomyopathy, and is not included into the above classification. Although new classifications have recently been proposed, the WHO/ISFC classification is still common in Japan and useful in the clinical setting. Figure 3 shows a flow chart of preoperative examinations for cardiomyopathy.

In management during the perioperative period of noncardiac surgery, arrhythmia and low cardiac output syndrome require special attention in patients with any type of cardiomyopathy. Extra vigilance is needed in patients with severe ventricular arrhythmia, which may cause sudden death. Patients often have been treated with oral antiarrhythmic drugs and may receive continuous intravenous lidocaine infusion during the perioperative period as needed, and many cases of arrhythmia are intractable. It is important to maintain normal sinus rhythm by adjusting electrolyte levels. If such treatment is impossible, heart rate should be controlled while in atrial fibrillation.

Low cardiac output syndrome in patients with dilated cardiomyopathy is treated by decreasing afterload with vasodilators and increasing cardiac contractile force with catecholamines and PDE III inhibitors, while such treatment is contraindicated in patients with hypertrophic cardiomy-
opathy and should be performed with care in patients with restrictive cardiomyopathy. Physicians should attempt to optimize intravascular volume to increase cardiac output regardless of the type of cardiomyopathy by managing intravascular fluid volume. However, since the range of the target intravascular volume is narrow, a pulmonary artery catheter should be placed to monitor hemodynamics carefully during the perioperative period, in which intravascular volume may change significantly, and diuretics should be administered whenever necessary.

Patients who had received warfarin to prevent embolism should be switched from warfarin to heparin infusion during the perioperative period. Adequate pain control is necessary, since postoperative pain increases afterload by increasing sympathetic activity.

9. Arrhythmias

In addition to myocardial infarction, arrhythmias and conduction disorders are quite common perioperative cardiac complications of noncardiac surgery. Arrhythmia may not occur as a single disorder. It is important to check for all possible heart diseases associated with arrhythmia when examining patients with perioperative arrhythmia.

| 9.1 Perioperative Arrhythmia and Its Treatment |

9.1.1 Assessment and Management of Preoperative Arrhythmias

When arrhythmia occurs in patients planned to undergo noncardiac surgery, physicians should check for the presence/absence of an underlying disease causing the arrhythmia and consider how to manage the patient should arrhythmia worsen during the perioperative period. The following types of organic heart disease may play roles in preoperative arrhythmia.

Sick sinus syndrome, atrioventricular block  
→ Coronary heart disease
Ventricular extrasystole (multifocal, sequential)  
→ Coronary heart disease, previous myocardial infarction, cardiomyopathy, aortic insufficiency

Atrial fibrillation  
→ mitral valve disease, hypertensive cardiac hypertrophy, constrictive pericarditis

There are reports suggesting that detailed monitoring and specific treatment are unnecessary in patients with preoperative ventricular extrasystole when myocardial infarction or other heart disease is absent. However, since arrhythmia may worsen during the perioperative period in patients with ischemic heart disease, appropriate examination should be performed to exclude possible diseases and uncover undiagnosed diseases.

For patients who have been diagnosed with arrhythmia and are taking antiarrhythmic drugs, physicians should consult with anesthesiologists to determine whether antiarrhythmic drugs should be given intravenously or be suspended during the perioperative period. Many believe that

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Table 14. Types and Causes of Perioperative Arrhythmias

<table>
<thead>
<tr>
<th>Arrhythmia</th>
<th>Causes</th>
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<tbody>
<tr>
<td>Sinus bradycardia</td>
<td>Vagal stimulation (e.g., stomach traction)</td>
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<tr>
<td>Sinus arrest</td>
<td>Carotid sinus reflex (during esophageal surgery)</td>
</tr>
<tr>
<td>Supraventricular extrasystoles</td>
<td>Atrial overload (excessive water intake)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>Hypokalemia, Mitral regurgitation, Hypertensive cardiac hypertrophy</td>
</tr>
<tr>
<td>Premature ventricular contraction</td>
<td>Ventricular overload (excessive water intake, pulmonary embolism)</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>Aortic regurgitation, Myocardial ischemia (myocardial infarction)</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>Myocardial ischemia (myocardial infarction), Cardiomyopathy (e.g., arrhythmogenic right ventricular dysplasia, long QT syndrome)</td>
</tr>
</tbody>
</table>

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Figure 3. Flow chart of evaluation for cardiomyopathy. NYHA, New York Heart Association; EF, ejection fraction.
beta blockers used before surgery should be continued during the perioperative period. In patients receiving anti-coagulation therapy to control atrial fibrillation, physicians should consider the benefits and risks of bleeding with anticoagulation therapy in determining a strategy of treatment for the perioperative period.

### 9.1.2 Arrhythmias That May Occur During Surgery

Table 14 lists conditions that may cause arrhythmias during the perioperative period. Although arrhythmias existing before surgery and underlying heart disease affect the type and incidence of arrhythmias during surgery, myocardial ischemia, overload on the heart, hypokalemia, and hypomagnesemia during surgery may induce arrhythmia. Anesthesic surgical procedures, and bleeding control also affect the incidence of arrhythmia during surgery. Since cardiac arrest may occur at the time of reperfusion during surgical treatment of intestinal ischemia or lower extremity ischemia, appropriate measures such as exsanguination of venous blood may be required.

Intraoperative bradycardia may be improved for a short period of time with atropine sulfate and beta-agonists. However, when bradycardia is prolonged or severe, patients may need ventricular pacing using transvenous leads inserted from the internal jugular vein, transesophageal pacing, or external pacing using chest patch electrodes.

### 9.1.3 Arrhythmias That May Occur After Surgery

The incidence of cardiac complications is highest during the first several days after surgery. Arrhythmias that may occur after surgery include those immediately after recovery from anesthesia, fatal arrhythmias due to pulmonary embolism, which is prone to occur during the first several days after surgery, and atrial fibrillation, the incidence of which is high during the first week after surgery.

Atrial fibrillation is clinically significant, since thrombus may develop in the left atrium and cause arterial embolism. Transesophageal echocardiography is useful to exclude possible arterial thrombus. Patients with atrial fibrillation may exhibit severe bradycardia requiring temporary pacing. Since severe and prolonged bradycardia may reflect the presence of latent conduction disorder, physicians should consider prompt implantation of permanent pacemakers.

### 9.2 Perioperative Management of Patients Using Implantable Pacemakers and Implantable Cardioverter Defibrillators

In patients with implantable pacemakers and implantable cardioverter defibrillators (ICD), electromagnetic interference and infection are the most important complications of noncardiac surgery. The use of electric knives may interfere with pacemakers, which will then not function properly. Unipolar devices are more susceptible to interference than bipolar devices. Physicians should be aware of the risk of electromagnetic interference when the surgical site is in close proximity to the pacemaker or leads. Physicians should also be familiar with the possible effects of use of electric knives at a surgical site distant from the pacemaker. Use of bipolar electric knives is in all cases the safest procedure, though such devices may make surgical procedures more complicated than unipolar devices. Pac ing mode must be adjusted during surgery if the surgical site is close to the pacemaker and requires frequent use of electric knives to stop bleeding. In patients who depend on a pacemaker to maintain heart rate, AOO, VOO, or DOO mode may be used during surgery. In patients in their own rhythm with the pacemaker in sense mode, the pacemaker is not used or is used with a low pacing rate during surgery.

In patients using an ICD, electromagnetic interference by electric knives may trigger the device, which may deliver a shock during surgery. In such patients, external patch electrodes should be placed on the chest wall to prepare for prompt electrocardioversion, and the ICD should be turned off during surgery. After surgery, the ICD should promptly be turned on. Continuous administration of antiarrhythmic drugs should be considered in patients susceptible to ventricular tachycardia. In any case, physicians and medical engineers with expertise in adjusting programs of implantable pacemakers and ICD should be present to support the surgery.

In patients undergoing gastrointestinal surgery and patients with traumatic open wounds, bacteremia may develop. When leads are exposed to venous blood for a long period of time, lead infection may occur, and the pacemaker may need to be removed. In patients with implantable pacemakers and ICD, antibiotic treatment should be initiated during surgery to minimize the occurrence of pacemaker infection. [end of part 2]-checked.

### 9.3 Management of Perioperative Arrhythmias in Patients With Long QT Syndrome and Brugada Syndrome

An implantable cardioverter defibrillator (ICD) is indicated for patients with long QT syndrome (QTc >440 msec) and a history of ventricular fibrillation or cardiac arrest. Congenital long QT syndrome consists of a group of conditions. Patients with congenital long QT syndrome associated with ventricular arrhythmia should be treated with beta blockers, mexiletine, or verapamil, according to the type of condition. Treatment with magnesium sulfate is effective for the treatment of acquired long QT syndrome.

Patients with Brugada syndrome are at risk of sudden death due to ventricular fibrillation. Oral drugs such as amiodarone and beta blockers are not effective in the treatment of Brugada syndrome. An ICD should be implanted before noncardiac surgery when the patient meets at least two of the following three conditions: (1) signs/symptoms of ventricular fibrillation or cardiac arrest; (2) a family history of sudden death; and (3) ventricular fibrillation induced during electrophysiological testing. Electrical defibrillation should be carried out when ventricular fibrillation develops.

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Appendix 1

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<th>Scholarship (educational) grant/endowed chair</th>
<th>Other rewards</th>
<th>Potential COI of the marital partner, first-degree family members, or those who share income and property</th>
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<td>Edwards Lifesciences St. Jude Medical</td>
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