Cardiac Surgery in Elderly Patients

Strategies to Optimize Outcomes

Donna Rosborough, RN, MS

An estimated 6.2 million inpatient cardiovascular operations and procedures are performed in the United States each year, accounting for 82,000 valve procedures and 516,000 coronary artery bypass graft (CABG) surgeries. Elderly patients undergoing surgery are a challenging group, and as the proportion of people 80 years and older continues to increase, so will the demand for cardiac surgery. However, because the mean life expectancy of a person 80 years old is approximately 88 years, many cardiologists are reluctant to refer elderly patients for elective surgery. Perceptions of elderly patients, their families, and their physicians that these patients may have lower functional reserve and more comorbid conditions, which are more likely to lead to complications or death, than younger patients have may make cardiologists and cardiac surgeons hesitant to offer elderly patients lifesaving or symptom-resolving cardiac surgery.

Elderly people are the fastest growing part of the US population. An estimated 10 million persons are 80 years or older; the fastest growing segment consists of persons 85 years and older. Compared with that of younger patients, the functional reserve of patients 85 and older is diminished, and elderly patients are more likely than younger patients to have chronic medical diseases such as diabetes, hypertension, and hyperlipidemia. However, because of advances in cardiopulmonary bypass technique, myocardial protection, and improved perioperative care, CABG and valve replacement operations can be safely offered to patients more than 80 years old.

Elderly cardiac patients require continuous clinical assessment and monitoring of body systems to prevent complications related to the surgery and cardiopulmonary bypass. Nurses need to educate patients and patients’ families about the plan of care and involve them in implementing the plan. In this article, I discuss the risks and benefits of cardiac sur-
surgery in elderly patients, describe the advent of new technology, and provide strategies for critical care nurses for the management of these patients.

**Background**

As the number of elderly patients undergoing CABG surgery and valve replacement continues to increase, evidence is growing that such surgery can result in improvements in health status, functional status, longevity, and quality of life in these patients. Although patients more than 80 years old are at increased risk for morbidity and mortality because of comorbid conditions such as diabetes mellitus, peripheral vascular disease, and renal dysfunction, especially in urgent or emergent cases, carefully selected patients may continue to lead a full life after recovery from cardiac surgery. Compared with younger patients, elderly patients have more postoperative complications and longer lengths of stay. These differences reflect the increased fragility of the organ systems in elderly patients and emphasize the need to anticipate events so they can be detected and managed early.

In a study of 220 patients 65 years or older at Yale–New Haven Hospital, New Haven, Conn, patients reported improved quality of life at 18 months after aortic and mitral surgery, and age did not appear to independently influence or limit the improvement in quality of life. Women have CABG and valve surgery at an older age than men do and with more cardiovascular risk factors. Use of hospital resources in terms of blood transfusions, mechanical ventilation, and length of intensive care unit and overall hospital stay tend to be greater for women than for men. Avery et al prospectedly studied 104 octogenarians who had cardiac surgery for comparison with a control group of 351 patients 65 to 75 years old. Compared with the younger group, the octogenarians had longer stays in the intensive care unit (69.2 vs 43.3 hours) and after surgery (10.09 vs 7.45 days) and were discharged to a skilled nursing facility more often (47% vs 21.1%).

At Brigham and Women’s Hospital in Boston, more than 1600 cardiac procedures are performed each year. The procedures include primary CABG surgery, valve surgery, surgery to repair congenital defects in adults, thoracic aortic surgery, cardiac transplantation, and implantation of cardiac assist devices. Often, cardiac surgery involves more than one of these procedures. The percentage of patients more than 80 years old and the percentage of patients having reoperations have both increased (Table 1).

**Table 1**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>1998</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>955</td>
<td>867</td>
</tr>
<tr>
<td>Men</td>
<td>578</td>
<td>556</td>
</tr>
<tr>
<td>Women</td>
<td>377</td>
<td>311</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean, overall</td>
<td>74</td>
<td>75</td>
</tr>
<tr>
<td>Mean, in men</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>Mean, in women</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Range, overall</td>
<td>65-93</td>
<td>65-95</td>
</tr>
<tr>
<td>Percentage &gt;80 years, overall</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Reoperations, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>In men</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>In women</td>
<td>9</td>
<td>15</td>
</tr>
</tbody>
</table>

**Vein Harvesting**

Endoscopic techniques for harvesting saphenous veins have decreased wound morbidity while preserving vein quality. In a study by Bitondo et al, the percentage of wound complications was significantly lower in patients who had endoscopic harvesting (6.8%) than in patients who had open harvesting (28.3%). The reported prevalence of leg wound complications for open harvesting of saphenous veins is 2% to 24%.

**Advances in Cardiac Surgery**

New and improved pharmacological agents, operative techniques, and improved technology have advanced cardiac surgery since the late 1960s. Advances in cardiac anesthesia and myocardial protection during cardiac surgery and in surgical techniques have improved morbidity and mortality statistics for all patients, including the elderly. However, cardiac tissues are often friable, and careful handling of the heart during all aspects of cardiac surgery is essential in elderly patients.

**Off-Pump CABG Surgery**

Off-pump CABG surgery has become a widely used technique because of complications due to the
systemic inflammatory response associated with cardiopulmonary bypass. These complications include coagulation disorders due to platelet defects and plasmin activation and pulmonary dysfunction due to sequestration and degranulation of neutrophils. Clinical characteristics of the systemic inflammatory response include pathological hypotension, fever of noninfectious origin, disseminated intravascular coagulation, diffuse tissue edema and injury, and in extreme cases, multiple organ failure, including the myocardium, the pulmonary system, the gastrointestinal tract, the brain, and the renal and circulatory systems. This renewed interest in off-pump CABG surgery has been attributed to several reasons: improvements in surgical and anesthetic techniques, economic advantages related to reductions in hospital length of stay and resource utilization, and minimization and/or elimination of risks associated with cardiopulmonary bypass. Elderly patients may benefit from off-pump CABG surgery because of heavily calcified aortas, history of impaired renal function with or without dialysis, and history of neurological disease such as transient ischemic attacks and cerebrovascular accidents. Since the introduction of devices for stabilizing the heart, off-pump CABG techniques have been advocated for elderly patients with comorbid conditions that were perceived to make the patients poor candidates for cardiopulmonary bypass. However, with off-pump CABG procedures, the quality and long-term patency of the anastomosis may be decreased; this possibility requires further investigation. More research is also needed on myocardial injury and postoperative arrhythmias, the systemic inflammatory response to organ damage, length of stay and hospital costs, early and late mortality, type and adequacy of revascularization, and indications for the use of off-pump CABG procedures.

Minimally Invasive Valve Surgery
The sudden increase in minimally invasive cardiac surgery was due in part to the need for shorter hospital stays, lower costs, and less trauma for patients. Minimally invasive CABG surgery began in the 1990s, creating a stimulus for performing primary valve surgery through incisions much smaller than the traditional median sternotomy incisions used in the past. At Brigham and Women’s Hospital, valve surgery through minimally invasive incisions began in 1996 for primary and reoperative valve procedures, especially in elderly patients who might have had previous CABG or valve surgery. In an initial study presented in 1997, a group of 50 patients undergoing the same operation through a median sternotomy were compared with the first 50 patients who had minimally invasive valve surgery, both aortic and mitral. The results indicated that blood transfusions, hospital stays, and hospital costs were reduced in the patients who had minimally invasive surgery, but more importantly, the patients recovered faster and returned to work more quickly (Table 2). When the study was repeated 1 year later with 100 patients in each group, the same conclusions were reached.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Minimally invasive (n = 50 patients)</th>
<th>Conventional (n = 50 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>35-83</td>
<td>24-85</td>
</tr>
<tr>
<td>Mean</td>
<td>61.0</td>
<td>60.3</td>
</tr>
<tr>
<td>Male, %</td>
<td>56</td>
<td>50</td>
</tr>
<tr>
<td>New York Heart Association classification, mean</td>
<td>2.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Cardiopulmonary bypass time, mean, min</td>
<td>143.44</td>
<td>104.2</td>
</tr>
<tr>
<td>Aortic cross-clamp time, mean, min</td>
<td>103.8</td>
<td>81.9</td>
</tr>
<tr>
<td>Percentage of patients in whom red blood cells used</td>
<td>52</td>
<td>62</td>
</tr>
<tr>
<td>Units of red blood cells used, mean</td>
<td>1.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Percentage of patients who had rehabilitation after discharge</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>No. of operative deaths</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No. of late deaths</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Transient ischemic attacks, No. of patients</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cardiovascular accidents, No. of patients</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Wound infections, No. of patients</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mean score on pain scale (range 0-10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In hospital</td>
<td>4.10</td>
<td>4.40</td>
</tr>
<tr>
<td>2 weeks after surgery</td>
<td>1.74</td>
<td>2.43</td>
</tr>
<tr>
<td>Return to work, weeks after surgery, mean</td>
<td>6.3</td>
<td>8.2</td>
</tr>
<tr>
<td>Return to normal activity, weeks after surgery, mean</td>
<td>4.6</td>
<td>9.4</td>
</tr>
<tr>
<td>Patient back to self, weeks after surgery, mean†</td>
<td>6.4</td>
<td>10.3</td>
</tr>
</tbody>
</table>

*P < .001.
†P = .009.
Outcome Measurements

Outcome measurements for elderly patients after cardiac surgery include length of stay, morbidity, mortality, and patients’ satisfaction. In a study by Kumar et al,14 octogenarians had significant improvements in New York Heart Association angina class, congestive cardiac failure class, number of cardiovascular signs and symptoms, and indices for satisfaction with overall life and general affect after cardiac operations. Setting expectations and providing the resources for effective management outside the hospital are critical for safely minimizing patients’ length of stay after cardiac surgery and ensuring successful outcomes.15 Enhanced communication between caregivers from the acute care setting through extended-care facilities and home care services is essential. Nurses are in a position to serve as advocates for elderly patients before and after cardiac surgery and must be skilled at assessing functional status and monitoring for indications of postoperative functional deficit.

Critical Pathways

Using a critical pathway has been one element in a multifactorial approach to improving efficiency and quality of care and reducing patients’ length of stay. Specific goals include the following16:
- selecting a “best practice” when practice styles vary unnecessarily,
- defining standards for the expected duration of hospital stay and for the use of tests and treatments,
- examining the interrelations among the different steps in the care process to find ways to coordinate or decrease the time spent in the rate-limiting steps,
- giving all hospital staff a common “game plan” from which to view and understand their roles in the overall care process,
- providing a framework for collecting data on the care process so that providers can learn how often and why patients do not follow an expected course during the patients’ hospitalization,
- decreasing the amount of documentation nurses and physicians must provide, and
- improving patients’ satisfaction with care by educating them and their families about the plan of care and involving both groups more fully in its implementation.

Monitoring Variances

Areas for process improvement and information needed to modify the critical pathway can be determined by monitoring variances from standard of care and postoperative complications. In a retrospective, nonexperimental study17 of 548 Medicare recipients (265 years) undergoing CABG during 1998, factors predictive of late extubation were age 80 years or older, being female, hypertension, urgent or emergent preoperative clinical status, and previous CABG surgery.

In cardiac surgery the most common outcomes affecting length of stay are atrial fibrillation and pleural effusion. Complications that occur more often in octogenarians than in younger patients are severe low-output state, reintubation, and atrial fibrillation.8

Atrial fibrillation occurs postoperatively in approximately 50% of patients after valve surgery and in 30% to 50% of patients after CABG surgery, leading to marked morbidity, including hypotension, heart failure, thromboembolic complications, prolonged hospital stay, and increased hospital costs.18,19 Arrhythmias are common because of intraoperative cardiac trauma, anesthetic agents, drugs, hypoxia, electrolyte and acid-base abnormalities, and the underlying heart disease. With advancing age, fibrosis in the atria increases, a situation that leads to side-to-side uncoupling of myocardial fiber bundles and development of nonuniform anisotropy, ultimately leading to reentrant excitation and atrial fibrillation.20

The management of atrial fibrillation should be based on the severity of the signs and symptoms. In most instances, however, initial treatment focuses on controlling the rapid ventricular response. The choice of antiarrhythmic agent should be based on the presence or absence of structural heart disease and the tolerability, ease of administration, and side effects of the agent.20 Pharmacological treatment with various antiarrhythmics (eg, procainamide, a class IA agent; propafenone, class IC; amiodarone, class III) has proven efficacy in maintaining normal sinus rhythm as does surgery to abolish atrial fibrillation by interrupting paths for reentry (ie, the Maze procedure in which lines of conduction block are created to isolate parts of the atria into areas too small to sustain reentry).21

Pleural effusion is common after cardiac surgery, occurring in 45% to 63% of cases.22 In CABG surgery, pleural effusion occurs primarily as a result of surgical excision of the internal mammary artery, which prevents alveolar expansion and predisposes patients to atelectasis. Treatment is diuresis and/or thoracentesis.
Cerebrovascular accidents are important complications of surgery in elderly patients. The increased incidence of strokes is expected in octogenarians because compared with younger persons, the elderly tend to have more advanced cerebral vascular disease, a greater incidence of cerebrovascular accidents, and more advanced aortic arteriosclerosis. Aortic calcification, older age, perioperative hypotension, and prolonged bypass time are important determinants of perioperative strokes.

In one study, only 2 variables, renal failure and urgent or emergent operation, were significant risk factors for early death in elderly patients after cardiac surgery.

### Education of Patients and Patients’ Families

Providing quality individualized care in a high-technology environment is a daily challenge. Providing such care begins with preoperative preparation of patients and their families. At Brigham and Women’s Hospital, my colleagues and I hypothesized that elderly women having cardiac surgery have an extended postoperative recovery time (in hospital and rehabilitation). A research analysis of 1620 patients who underwent cardiac surgery between July 1, 2000, and June 30, 2001, was performed to examine the influence of age, sex, and type of procedure on postoperative recovery and need for rehabilitation (Table 3). The mean length of stay in the intensive care unit and in the hospital from day of surgery to day of discharge was greater in patients who had combined valve and CABG surgery than in patients who had other types of cardiac surgery and in patients more than 65 years old. We concluded that the need for rehabilitation depends on the association between being female, older age, type of operative procedure, and hospital length of stay. We use predicted outcomes to plan management of patients after surgery and after discharge from the hospital.

Education of patients and their families is another key component in cardiac surgery. Education begins when a patient is referred for surgery. At Brigham and Women’s Hospital, patients and their families receive preoperative and postoperative educational materials written by cardiac surgeons and nurses to provide a detailed description of cardiac surgery. Patients who are having elective surgery have a preoperative evaluation in the preadmission test center that includes physical examination, tests, and an educational overview of what to expect before and after surgery. Classes after surgery are held in the intermediate care unit Monday through Friday. Patients and their families attend the classes before discharge as an adjunct to the written educational materials. At the time of discharge, each patient receives a videotape to review and reinforce postoperative recovery.

Psychological depression is common after coronary surgery, especially in elderly patients. Patients need education and reinforcement that depression is a normal response to a major cardiovascular event. Elderly patients also have an increased incidence of noncompliance with their medications. Because of the high cost of the drugs, many elderly patients, who often have a fixed income, may not have their prescriptions filled. Other factors predictive of poor compliance include a complicated drug regimen, use of multiple drugs, not understanding the instructions, mental impairment, visual or hearing disabilities, and not having a helper or relative at home.

Discharge planning is an integral part of patients’ hospitalization for cardiac surgery. With the increasing acuity of patients who have open heart surgery yet shorter lengths of stay and more restrictions by third-party payers on assessing postoperative patients at home, the ability of patients to manage at home after cardiac surgery is a concern. At Brigham and Women’s Hospital, the standard of care is that all patients

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### Table 3 Risk factors predictive of postoperative recovery and need for rehabilitation after cardiac surgery, July 1, 2000 to June 30, 2001, in 1620 patients

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Sex</th>
<th>No. of patients (%)</th>
<th>Operative mortality,</th>
<th>Mean length of stay, d</th>
<th>Percentage of patients who had rehabilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤65</td>
<td>Male</td>
<td>520 (32.1)</td>
<td>2.7</td>
<td>2.3</td>
<td>8.0</td>
</tr>
<tr>
<td>≤65</td>
<td>Female</td>
<td>197 (12.2)</td>
<td>1.8</td>
<td>1.1</td>
<td>11.6</td>
</tr>
<tr>
<td>&gt;65</td>
<td>Male</td>
<td>554 (34.2)</td>
<td>3.3</td>
<td>3.0</td>
<td>42.2</td>
</tr>
<tr>
<td>&gt;65</td>
<td>Female</td>
<td>349 (21.5)</td>
<td>5.4</td>
<td>3.9</td>
<td>56.7</td>
</tr>
</tbody>
</table>

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are discharged home with visiting nurse services or to an extended care facility if more intensive medical management and rehabilitation services are required. To provide ongoing reinforcement of discharge information and early intervention for any issues, a nurse from the cardiac surgery office contacts all patients discharged to home and contacts rehabilitation nursing staff for patients discharged to an extended care facility.

Elderly cardiac surgery patients need targeted discharge planning to answer questions about medications, infection, pain, and scheduling of follow-up appointments with physicians. The overall focus for cardiac rehabilitation and exercise training in elderly patients should be to enhance health-related conditioning while simultaneously reducing risk factors for chronic diseases and improving the overall quality of life.26

**Conclusion**

Early referral of patients before severe cardiac dysfunction is mandatory to improve immediate survival after surgery and ensure long-term benefits of surgery.27 Elderly patients undergoing cardiac surgical procedures require intensive quality nursing care. Understanding the advanced cardiac surgical procedures and the evolution of new technology can enable critical care nurses to provide effective and safe care, preventing complications and providing accurate information to patients and patients’ families. The quality of patients’ outcomes should be monitored to reduce morbidity and mortality, decrease hospital length of stay, and improve patients’ satisfaction. Because of the increased cost of delivering healthcare, careful follow-up of elderly patients after cardiac surgery is required to continually reevaluate the benefit obtained from the surgery.4

Because of the rapid increases in the number of older persons, the prevalence of cardiac abnormalities, and life expectancy, the number of elderly patients referred for cardiac surgery most likely will increase. With the gain in the proportion of the population of patients 80 years and older, the high incidence of heart disease in the elderly, and the increasing impact of managed care on the delivery of medical services, the relative value of cardiac procedures will become an increasingly important issue.28 Randomized clinical trials of medical versus surgical palliation of cardiovascular signs and symptoms in octogenarian patients are needed to justify cost-effectiveness and guide better use of relatively scarce Medicare resources.29 Unfortunately, elderly patients have been significantly underrepresented in the randomized trials of revascularization for coronary disease.

Morbidity and mortality after cardiac surgery depend on the presence of comorbid conditions, ejection fraction, and diffuseness of coronary artery disease but are generally higher in elderly patients than in younger patients.24 Elderly patients and their families should be educated about the expected health status benefits and the clinical predictors of mortality and morbidity associated with cardiac surgery. Unfortunately, healthcare providers have been reluctant to consider surgical therapy in octogenarians until medical therapy has been exhausted, at which point the patient is often a relatively poor candidate for surgery. The findings from various studies should guide cardiac surgeons in making informed decisions about recommendations for surgery.

The overall improvement in outcomes for older patients may be due to better selection of very elderly patients undergoing surgery or to the increased experience and skill acquired by operating on more octogenarians over time.30 Because octogenarians are close to their maximum life expectancy, emphasis on long-term survival in these patients after heart surgery may not be appropriate.2

**References**

12. Chen-Scarabelli C. Beating-heart coronary artery bypass graft surgery: indications,


1. What is the number of valve procedures and coronary artery bypass graft (CABG) surgeries performed each year?
   a. 70,000 valve procedures and 800,000 CABG surgeries
   b. 82,000 valve procedures and 516,000 CABG surgeries
   c. 500,000 valve procedures and 76,000 CABG surgeries
   d. 269,000 valve procedures and 527,000 CABG surgeries

2. What is the fastest growing segment of the US population?
   a. 65 to 75 years of age
   b. 70 to 75 years of age
   c. 85 years of age or older
   d. 78 years of age or older

3. Which of the following is not a reason CABG and valve replacement surgeries can be offered to patients 80 years or older?
   a. Advances in cardiopulmonary bypass techniques
   b. Medicare has increased reimbursement
   c. Economic advantages related to reductions in length of stay and improvements in surgical and anesthetic care
   d. Improved perioperative care

4. Which of the following is not a comorbid condition for the elderly undergoing valve replacement or CABG surgery?
   a. Diabetes mellitus
   b. Peripheral vascular disease
   c. Renal dysfunction
   d. Chronic obstructive pulmonary disease

5. Which of the following was not found in the Avery study, comparing patients aged 65 to 75 years old with octogenarians undergoing valve or CABG surgery?
   a. Octogenarians had a shorter hospital length of stay.
   b. Octogenarians had a longer hospital length of stay.
   c. Octogenarians had a longer length of stay in the intensive care unit.
   d. Octogenarians were discharged to skilled nursing facility more often.

6. Which of the following have resulted in renewed interest in off-pump CABG surgery?
   a. Improvements in Medicare reimbursement and improvements in surgical and anesthetic care
   b. Elimination of risks associated with CABG surgery and improvements in Medicare reimbursement
   c. Economic advantages related to reductions in length of stay and improvements in surgical and anesthetic care
   d. Elimination of risks associated with CABG surgery and increased health status of octogenarians

7. What are the outcome measures for elderly patients after CABG surgery?
   a. Intensive care unit length of stay, mortality, patient satisfaction
   b. Length of stay, family satisfaction, decreased nursing home discharges
   c. Length of stay, morbidity and mortality, patient satisfaction
   d. Family satisfaction, length of stay, morbidity and mortality

8. Which of the following is not a specific goal of critical pathways with elderly CABG patients?
   a. Allowing the patient to make decisions with guidance from the staff
   b. Giving hospital personnel a game plan
   c. Providing a framework for data collection
   d. Decreasing documentation

9. What process is used to gather information to modify the critical pathway?
   a. Patient interviewing
   b. Formal needs assessment
   c. Monitoring variances
   d. Chart reviews

10. What are the 2 most common outcomes affecting length of stay in elderly CABG patients?
    a. Atrial fibrillation and pleural effusions
    b. Atrial fibrillation and renal failure
    c. Renal failure and pleural effusions
    d. Pleural effusions and wound infections

11. What is the percentage of patients who develop atrial fibrillation after CABG surgery?
    a. 46% to 58%
    b. 78% to 90%
    c. 30% to 50%
    d. 25% to 76%

12. Which of the following is not a reason octogenarians have increased incidence of stroke?
    a. More advanced cerebral vascular disease
    b. Diabetes mellitus
    c. More cerebrovascular accidents
    d. More arteriosclerosis

13. Which of the following criteria are thought to increase morbidity and mortality in elderly patients following CABG surgery?
    a. Presence of comorbid conditions, ejection fraction, and diffuseness of coronary artery disease
    b. Ejection fraction, diffuseness of coronary artery disease, and diabetes mellitus
    c. Acute renal failure, diabetes mellitus, and presence of comorbid conditions
    d. Ejection fraction, diabetes mellitus, and acute renal failure
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