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Health Expenditure and Technology Project

Technologies used for managing and preventing acute myocardial infarction

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Foreword

The Health Expenditure and Technology (HEAT) Project is being undertaken jointly by the Institute of Health Economics and the Alberta Heritage Foundation for Medical Research at the request of Alberta Health (now Alberta Health and Wellness). Alberta Health had asked that a methodological framework be developed for the determinants and financial consequences of technological change in health care. As an initial study, technologies used in the management of acute myocardial infarction are being considered. It is expected that this project will provide a model for future studies on health technology and expenditure associated with other diseases and conditions.

Contents

Introduction

This paper has been prepared as a brief introduction to the HEAT project to provide a concise outline of health technologies used in the management of acute myocardial infarction (AMI) which might be expected to have a significant economic impact on the health care system in Alberta.

The approach taken in the HEAT project is based on events that take place during an *episode* of AMI. An episode is defined as the time from first contact of the patient in the emergency department of a health care facility to the conclusion of his/her rehabilitation program.

Treatment of AMI is technology-intensive. The technologies used include drugs, devices, procedures and equipment which may be used for preventive interventions, diagnosis, treatment (including intensive care) and rehabilitation.

Nearly 45,000 Canadians were discharged from hospital with a primary diagnosis of AMI during 1993/94. According to Statistics Canada, the projected number of patients with AMI and the number of hospital days will increase by approximately 36% each decade to the year 2026. As coronary heart disease is age related, the estimated portion of the Alberta population at risk between the ages of 45 and 65 years will be increasing by approximately 90% from 1986 to 2011.

In the preparation of this paper, the most recent guidelines of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines were used as the main reference source. In addition, experts in cardiology in Alberta were consulted regarding provincial practice patterns over the past ten to fifteen years.

Patient selection

Not all patients diagnosed with AMI are alike. Those diagnosed with AMI on entry into the medical care system differ considerably from those whose diagnosis becomes evident late after admission. In such cases, AMI appears not as the admission diagnosis but only as the discharge diagnosis.

According to the World Health Organization, the diagnosis of AMI is based on the presence of at least two of the following three criteria:

- clinical history of ischemic type chest discomfort;
- changes in serially obtained ECG tracings, and
- rise and fall in serum cardiac markers.

Approximately 70% to 80% of patients with AMI present with ischemic type chest discomfort. However, less than 25% of patients admitted to the hospital with ischemic type chest discomfort are subsequently diagnosed as having had an AMI. A practical division of all patients with AMI is to classify them on the basis of ECG findings as those with segment elevation and those without it. Although ST-segment elevation and/or Q waves on the ECG are highly indicative of AMI, more than 50% of patients with AMI do not exhibit ST-elevation but display other or non-diagnostic ECG changes. Physicians must rely heavily on their clinical judgement to determine which patients require hospitalization and which can safely be sent home.

Treatment

Standard treatment for patients presenting with AMI ST–segment elevation or new left-bundle-branch block includes the administration of oxygen by nasal prongs to provide rapid relief of breathlessness, anxiety and pain. Other medications, such as morphine or meperidine, are provided as indicated for analgesia. ASA is provided to inhibit platelet aggregation and limit thrombus propagation. Other available antiplatelet agents are dipyridamole, ticlopidine and clopidogrel.

All patients presenting with AMI are considered for *thrombolytic therapy*. Thrombolytic therapy (streptokinase or tissue-type plasminogen activator) limits the extent of necrosis or salvages at-risk myocardium by lysing blood clots, thus restoring blood flow. Heparin may be used in conjunction with thrombolytic agents. It inhibits several important coagulation factors, reducing thrombin formation or propagation and prevents reocclusion after successful reperfusion. Low molecular weight heparin may become the preferred approach over conventional unfractionated. Benefits may include the potential to prevent thrombin generation, the lack of need to monitor with coagulation testing and a lower rate of thrombolytopenia associated with heparin use.

Patients without contraindications (CHF or cardiogenic shock) should immediately receive *intravenous beta-adrenergic receptor blockers* (propranolol, atenolol, metoprolol) when AMI is suspected, followed by oral agents when the patient is hemodynamically stable. The activation of beta receptors results in relaxation of the bronchial muscles and an increase in the rate and force of cardiac contraction.

ACE inhibitors (ramipril; zofenopril; enalapril; quinapril) should be initiated within hours of hospitalization for patients with LV dysfunction. ACE inhibitors decrease mortality in patients with LV systolic dysfunction.

For the first 24 to 48 hours, intravenous or topical *nitroglycerine* may be used for hypertensive patients, those with ischemia, patients with large anterior infarctions, acute CHF and normotensive patients with heart failure. The fundamental action of nitrates is to direct vasodilation by smooth muscle relaxation. These are non-selective vasodilators affecting veins, arteries and arterioles.

Calcium channel blockers (verapamil; diltiazem; nifedipine; amlodipine) should not be used in the routine management of AMI. They may provide relief of ongoing ischemia or rate control of atrial fibrillation in patients who are hemodynamically stable with preserved LV systolic function. Calcium channel blockers act by dilating blood vessels and reducing myocardial oxygen demand.

Antiarrhythmic agents (lidocaine; bretylium; procainamide; amiodarone) are used intravenously for life threatening or severely symptomatic arrhythmias if chest

Hospital Management

Diagnostic tests

Commonly performed diagnostic tests during hospitalization include serum electrolytes, coagulation monitoring tests and the determination of magnesium levels.

The *balloon flotation catheter* is helpful for diagnosis and hemodynamic monitoring such as pulmonary-arterial pressure and cardiac output to direct therapy in critically ill patients. The *pulse oximeter*, another monitoring device, provides early warning of hypoxemia.

Mechanical defects such as acute mitral valve regurgitation, post infarction interventricular septum defect (VSD), left ventricle (LV) free wall rupture and LV aneurysm, can occur within the first week after AMI. A diagnosis can be established with transthoracic or transesophageal echocardiography.

Survivors of AMI who have preserved LV systolic function and spontaneous or provoked ischemia in the days to weeks after AMI undergo elective angiographic evaluation with subsequent consideration for percutaneous or surgical revascularization. *Coronary angiography* is the gold standard for diagnosing coronary artery disease. It delineates the presence of surgically or angioplasty correctable coronary artery disease.

Coronary angiography shows how many coronary arteries are blocked, which arteries are affected and the severity of the blockages. The procedure involves the insertion of a catheter into an artery (usually in the groin but sometimes in the arm) to the heart. A dye is injected through the catheter. X-ray imaging (angiograms) is then used to view the blood flow through the heart and locate the arteries with blockages.

Treatment

Intraoperative myocardial preservation strategies

Circulatory support devices such as prosthetic ventricles, the LV turbine (Hemopump) and percutaneous cardiopulmonary bypass circuits have been used in patients with cardiogenic shock resulting from AMI or unstable ischemic syndrome, as a bridge to definitive revascularization or cardiac transplantation.

Ventricular assist devices (VAD) support ventricular function by assisting ventricular contractions or by bypassing the affected, dysfunctional ventricle and performing the actual pumping. This assist enables the heart to sufficiently support the body's needs. The VAD can be used until a new heart becomes available, until the heart recovers its functionality and does not require

role of intracoronary stenting in AMI remains unproven. Studies are also needed to determine the relative importance of operator experience.

Pacemakers and other forms of treatment

The *cardiac pacemaker* uses electrical impulses to reproduce or regulate the rhythms of the heart. It may be temporary or permanent and is inserted transvenously, transcutaneously, epicardially, or via the esophagus or coronary artery. The temporary pacemaker is best provided in an intensive care unit setting. Indications for permanent pacing after AMI in patients experiencing conduction disturbances are related primarily to the degree and type of atrioventricular (AV) block and the location of the MI, and do not necessarily depend on the presence of symptoms.

Transcutaneous pacemaker systems are suitable for providing standby pacing in potentially unstable AMI patients, especially those not requiring immediate pacing and at only moderate risk of progressing to AV block. Transcutaneous systems are available that use a single pair of multifunctional electrodes that allow electrogram monitoring, transcutaneous pacing and defibrillation as needed.

Other surgical procedures used less frequently include: pericardiocentesis (surgical puncture of the pericardial cavity for the aspiration of fluid); emergency mitral valve replacement plus CABG for acute mitral valve regurgitation; emergency surgical repair with simultaneous CABG for post infarction VSD; and repair of the ventricle using a direct suture technique or patch in addition to CABG for LV free wall rupture. *Artificial heart implantation* may be used as a bridge to heart transplantation for patients who sustained irreversible acute myocardial injury.

Cardiac rehabilitation

Cardiac rehabilitation combines prescriptive exercise training with education about coronary risk factor modification techniques. Rehabilitation programs focus on nonpharmacological interventions: exercise, weight management, dietary modifications, stress management and smoking cessation. Formal rehabilitation programs are intended to effectively improve functional capacity, promote compliance, decrease emotional distress, improve quality of life, reduce cardiovascular mortality, mitigate ischemic symptoms, promote reversal of atherosclerosis, and reduce risk of subsequent coronary events.

In a US study, psychological distress was found to be the most important predictor of hospitalization costs following a cardiac event. Psychologically distressed cardiac patients accrued more than four times the costs for non-psychiatric medical interventions. However, the optimal mix of exercise, psychological and educational intervention remains to be answered as do the frequency and duration of the program. Three to five supervised exercise sessions per week are recommended, in combination with patient education and/or psychosocial interventions, for a period of approximately 12 weeks.

Appendix A: The history of technologies for AMI

1920s- 1930s - Physicians came to rely on the electrocardiogram (ECG) to assist in recognizing AMI. In patients with pulmonary rales, digitalis was given. Nitrates and morphine were prescribed for pain. Caffeine and camphor were used to prevent hypotension, syncope and heart block. Use of quinidine for the treatment of ventricular tachycardia and intra muscular adrenaline to treat heart block and syncope. The introduction of the routine administration of oxygen following AMI.

1940s – During this period the main event was the development and introduction of anticoagulants, heparin and bishydroxy coumarin (dicumarol).

1950s – Subcutaneous atropine and papaverine followed by sublingual nitroglycerin (glyceryl trinitrate) were used to prevent or relieve coronary spasm. Use of anticoagulants to prevent reinfarction, mural thrombosis, and pulmonary embolism. The electric defibrillator used for the treatment of ventricular tachycardia and ventricular fibrillation. Electronic pacemakers used for the treatment of symptomatic bradycardia.

1960s – One of the major advances of this decade was the introduction of valve surgery and catheterization laboratories. The concept of the coronary care unit to improve survival (reduced mortality from about 30% to 15%) following AMI came about as a result of four separate developments. These include recognition of the importance of arrhythmias as the principal cause of early death; the ability to monitor the ECG continuously with the cathode-ray oscilloscope; the development of closed-chest cardiac resuscitation; and the delegation of the treatment of life-threatening arrhythmias to trained nurses in the absence of physicians.

The development of the "crash cart", a large mobile cabinet that included a defibrillator, thoracotomy instruments, intubation and tracheostomy equipment, a temporary pacemaker, and several cardiac drugs (epinephrine, calcium chloride, quinidine gluconate, procainamide, digitoxin, levophed and other vasopressors). Tests to identify and quantify myocardial necrosis using serum enzyme assays, radioisotopes and angiocardiography became available.

1970s –The invention of the balloon-tipped, flow directed cardiac catheter for continuous online monitoring of intra cardiac pressures. The Swan-Ganz catheter gave clinicians a tool to tailor therapies specifically to the function of the cardiac pump. Interventions could now be selected to address specific hemodynamic abnormalities. These interventions consisted of intra-aortic balloon counterpulsation, intravenous administration of fluid or diuretics to optimize ventricular pre-load, vasopressors or vasodilators to optimize systemic vascular resistance and left ventricular after-load; and positive inotropic agents

patients with chest pain or other symptoms suggestive of acute cardiac ischemia.

- The introduction of a laser procedure, transmyocardial revascularization, for patients with stable angina who are unable to obtain symptom relief with medication and cannot undergo revascularization procedures such as bypass surgery.
- The eradication of *Chlamydia pneumoniae* with macrolide antibiotics is still under study. More research is needed to support an infectious origin for atherosclerotic disease and clinical trials to demonstrate that antibiotics might help to prevent cardiovascular events.
- Oral glycoprotein IIb/IIIa blockers (abciximab, eptifibatide, tirofiban), which inhibit platelet aggregation and thrombus formation, are used in the prevention of infarction and reinfarction. Use in routine clinical practice is still controversial as the appropriate dose and timing of administration must be determined. These agents have the potential for enhancing reperfusion with primary PTCA or with thrombolytic agents. Some centres throughout the province are using these agents. The recent updated ACC/AHA guidelines suggest their use for MI patients without ST-segment elevation who have some high risk factors and/or refractory ischemia but do not have a bleeding risk.
- Move towards initiating treatment of infarction in the home. Paramedics will conduct ECGs on site, which will be overviewed, and thrombolytic therapy will be provided as appropriate before transport to hospital. New thrombolytic agents that may be administered as a single bolus are currently undergoing study. These new agents have the advantage of rapid, easy administration and the potential for more complete, rapid restoration of blood flow to the infarct-related vessels.
- Research is ongoing in two areas of gene therapy: to stimulate growth of new blood vessels to bypass blocked vessels and genetic engineering as an approach to prevent blockages or restenosis after CABG.
- Photoangioplasty, using lutetium texaphyrin (Antrin), helps remove arterial blockage. This drug kills cells that have absorbed it when the cells are exposed to high-intensity red light. The drug is specific and is absorbed by cells that play a role in plaque formation.

- Surgical repair of septal defect
- Surgical repair of ventricle

Discharge Evaluations

- Myocardial perfusion scintigraphy
- Exercise electrocardiography
- Pharmacological stress agents with perfusion imaging or Echocardiography
- Holter monitoring
- Radionuclide angiocardiography or Echocardiography
- Radionuclide ventriculography
- Coronary arteriography (variation on angiography)

Cardiac Rehabilitation

- Exercise and education program with professional 3 to 4 times per week for 3 months
- Two week intensive program for out of town patients

Secondary Prevention

- Risk factor reduction clinics
- Cholesterol levels: statins, cholestyramine, colestipol, fibrates
- Homocysteine, folic acid
- Nicotine gum, bupropion and nicotine patches
- Aspirin, ACE inhibitors, β-adrenoceptor blockers (atenolol, metoprolol, propranolol, timolol), warfarin.

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