Cardiogenic shock is a state of inadequate tissue perfusion due to cardiac dysfunction, usually secondary to acute myocardial infarction. Shock, in turn, is the most common cause of death in hospitalized patients with acute myocardial infarction; reported mortality rates range from 50% to 80%. Despite recent advances in the care of patients with acute coronary disease and the benefits associated with the early use of reperfusion strategies, cardiogenic shock as a complication of acute myocardial infarction continues to be associated with a dismal prognosis. With improvements in electrocardiographic monitoring and the treatment of life-threatening ventricular arrhythmias, cardiogenic shock has emerged as the most common cause of death among patients admitted to the hospital with acute myocardial infarction. The incidence of Cardiogenic shock complicating acute myocardial infarction ranges from 5 to 10 percent. Rapid evaluation and prompt initiation of supportive measures and definitive therapy in patients with cardiogenic shock may improve early and long-term outcomes.

Definition

The clinical definition of Cardiogenic shock is decreased cardiac output and evidence of tissue hypoxia in the presence of adequate intravascular volume. Hemodynamic criteria are sustained hypotension (systolic blood pressure < 80 mm Hg for at least 30 minutes) and a reduced cardiac index (1.8 L/min per m²) in the presence of elevated pulmonary capillary occlusion pressure (≥18 mm Hg). Circulatory shock is diagnosed at the bedside by observing hypotension and clinical signs indicating poor tissue perfusion, including oliguria; clouded sensorium; and cool, mottled extremities. Cardiogenic shock is diagnosed after documentation of myocardial dysfunction and exclusion or correction of such factors as hypovolemia, hypoxia, and acidosis.

Table 1: Definition of cardiogenic shock

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Cardiac output index</td>
<td>&lt;1.8/min/m²</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>&lt;80 mm of Hg</td>
</tr>
<tr>
<td>Left atrial pressure</td>
<td>&gt;18 mm of Hg</td>
</tr>
<tr>
<td>Urine output</td>
<td>&lt; 20 ml/hr</td>
</tr>
<tr>
<td>Systemic vascular resistance</td>
<td>&gt;2000 dynes-sec-cm³</td>
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Incidence
The precise incidence of the cardiogenic shock is difficult to measure because patients not reaching hospital before death are not given the diagnosis. Recent estimates of the incidence of cardiogenic shock have ranged from 5% to 10% of patients with myocardial infarction. The Worcester Heart Attack Study, a community wide analysis, found an incidence of cardiogenic shock of 7.5%; and this incidence remained stable from 1975 to 1988. In the Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Arteries (GUSTO-1) trial, the incidence of cardiogenic shock was 7.2%, a rate similar to that found in other multicenter thrombolytic trials.

Causes
The most common cause of cardiogenic shock is extensive acute myocardial infarction, although a smaller infarction in a patient with previously compromised left ventricular function may also precipitate shock. Shock that has a delayed onset may result from infarct extension, reocclusion of a previously patent infarct related artery, or decompensation of myocardial function in the noninfarction zone because of metabolic abnormalities. It is important to recognize that large areas of nonfunctional but viable myocardium can also cause or contribute to the development of cardiogenic shock in patients after myocardial infarction. Cardiogenic shock can also be caused by mechanical complications - such as acute mitral regurgitation, rupture of the interventricular septum, or rupture of the free wall - or by large right ventricular infarctions.

Other causes of cardiogenic shock include myocarditis, end-stage cardiomyopathy, myocardial contusion, septic shock with severe myocardial depression, myocardial dysfunction after prolonged cardiopulmonary bypass, valvular heart disease, and hypertrophic obstructive cardiomyopathy.
SHOCK (SHould we emergently revascularize Occluded Coronaries for shock) trial registry of 1160 patients with cardiogenic shock, 74.5% of patients had predominant left ventricular failure, 8.3% had acute mitral regurgitation, 4.6% had ventricular septal rupture, 3.4% had isolated right ventricular shock, 1.7% had tamponade or cardiac rupture, and 8% had shock that was a result of other causes.

In the SHOCK trial registry, 75% of patients developed cardiogenic shock within 24 hours after presentation of AMI; the median delay was 7 hours from onset of infarction. Results from the GUSTO trial were similar: among patients with shock, 11% were in shock on arrival and 89% developed shock after admission. Cardiogenic shock evolves over a time period and only a few patients present with shock as initial presentation.

Cardiogenic shock is most often associated with anterior myocardial infarction. In the SHOCK trial registry, 55% of infarctions were anterior, 46% were inferior. These findings were consistent with those in other series. Angiographic evidence most often demonstrates multivessel coronary disease (left main occlusion in 29% of patients, three-vessel disease in 58% of patients, two-vessel disease in 20% of patients, and one-vessel disease in 22% of patients).

**Pathophysiology**

The underlying pathophysiology of CS is profound depression of myocardial contractility, resulting in a vicious spiral of reduced cardiac output (CO), low blood pressure, further coronary insufficiency,
and further reduction in contractility and CO. The classic paradigm predicts that compensatory systemic vasoconstriction with high systemic vascular resistance (SVR) should occur in response to the depression of CO (Figure 1). Autopsy studies have shown that the pathological basis of CS is extensive MI. Varying pathological stages of infarction confirm the stuttering and progressive nature of the myocardial necrosis as a corollary of the vicious spiral. Combined new and old infarctions consistently involve at least 40% of the LV myocardium in these autopsy specimens.

But recently Hochman challenged this classic paradigm, and described a new Paradigm. Basis for this new paradigm was several observations derived from the SHOCK (SHould we emergently revascularize Occluded Coronaries in cardiogenic shocK?) trial and registry about patients with cardiogenic shock due to LV failure not easily explainable by our traditional concepts. These include the following:

1. Average LV ejection fraction (EF) is only moderately severely depressed (30%), with a wide range of EFs and LV sizes noted.
2. SVR on vasopressors is not elevated on average, with a very wide range of SVRs measured.
3. A clinically evident systemic in ammatory response syndrome is often present in patients with CS.
4. Most survivors have class I congestive heart failure (CHF) status.

From these observations he suggested role of cytokines in the pathogenesis of cardiogenic shock. Patients post-MI have activation of in ammatory cytokines leads to high levels of iNOS, NO, and peroxynitrile, all of which have multiple deleterious effects like
- Direct inhibition of myocardial contractility
- Suppression of mitochondrial respiration in nonischemic myocardium
- Effects on glucose metabolism
- Proin ammatory effects
- Reduced catecholamine responsiveness
- Induction of systemic vasodilation

Clinical assessment
As early as 1912, Herrick described the clinical features of cardiogenic shock in patients with severe coronary-artery disease: a weak, rapid pulse; feeble cardiac tones; pulmonary rales; dyspnoea; and cyanosis. Systemic hypotension is generally regarded as essential to the diagnosis of the syndrome. The clinical picture remains the same even today.

Cardiogenic shock is an emergency. The clinician must initiate therapy before shock irreversibly damages vital organs; at the same time, he or she must perform the clinical assessment required to understand the cause of shock and target therapy to that cause.

A practical approach is to make a rapid initial evaluation on the basis of a limited history, physical examination, and specific diagnostic procedures (Fig 2). Cardiogenic shock is diagnosed after documentation of myocardial dysfunction and exclusion of alternative causes of hypotension, such as hypovolemia, hemorrhage, sepsis, pulmonary embolism, tamponade, aortic dissection, and preexisting valvular disease.

Patients with shock are usually ashen or cyanotic and can have cool skin and mottled extremities. Cerebral hypoperfusion may cloud the sensorium. Pulses are rapid and faint and may be irregular if arrhythmia is present. Jugular venous distention and pulmonary rales are usually present, although their absence does not exclude the diagnosis. A precordial heave resulting from left ventricular dyskinesis may be palpable. The heart sounds may be distant, and third or fourth heart sounds, or both, are usually present. A systolic murmur of mitral regurgitation or ventricular septal defect may be heard, but these complications also occur without an audible murmur.

Electrocardiography should be performed immediately; other initial diagnostic tests usually include chest radiography and measurement of arterial blood gas, electrolytes, complete blood count, and cardiac enzymes.

Echocardiography is an excellent initial tool for confirming the diagnosis of cardiogenic shock and ruling out other causes of shock; therefore, early echocardiography should be routine. Echocardiography provides information on overall and regional systolic function and can lead to a rapid diagnosis of mechanical causes of shock, such as papillary muscle rupture and acute mitral regurgitation, acute ventricular septal defect, and free-wall rupture and tamponade. Unsuspected severe mitral regurgitation is not uncommon. In some cases, echocardiography may show findings that are compatible with right ventricular infarction.

Invasive hemodynamic monitoring can be useful to exclude volume depletion, right ventricular infarction, and mechanical complications. The hemodynamic profile of cardiogenic shock includes a pulmonary capillary occlusion pressure greater than 18 mm Hg and a cardiac index less than 1.8
L/min per m². It should be recognized that optimal filling pressures may be greater than 18 mm Hg in individual patients because of left ventricular diastolic dysfunction. Right-heart catheterization may show a “step-up” in oxygen saturation at RV and PA level that is diagnostic of ventricular septal rupture or a large “V” wave in PCWP tracing that suggests severe mitral regurgitation. The hemodynamic profile of right ventricular infarction includes high right-side filling pressures in the presence of normal or low occlusion pressures.

Treatment and outcome

Trends in outcome
The outcome of cardiogenic shock complicating acute coronary syndromes seems to have improved during last 2 decades, with the greatest improvement in the past decade (1990s). The in-hospital death rate among patients with cardiogenic shock was greater than 70% from 1975 to 1990, but declined to 59% in 1997. This trend was evident despite the fact that, in the later years, patients with shock were older and sicker. Similarly, the outcome of patients with myocardial infarction and shock has improved in periodic surveys conducted in Israel, with 30-day mortality rates of 87% in 1992, and 73% in 1996.⁷
Initial Management

General Stabilization
The initial approach to the patient in cardiogenic shock should include fluid resuscitation unless pulmonary edema is present. Central venous and arterial access, bladder catheterization, and pulse oximetry are routine. Oxygenation and airway protection are critical; intubation and mechanical ventilation are often required, if only to reduce the work of breathing and facilitate sedation and stabilization before cardiac catheterization. Electrolyte abnormalities should be corrected. Hypokalemia and hypomagnesemia are predisposing factors to ventricular arrhythmia, and acidosis can decrease contractile function.

Drug Therapy

Painkillers
Relief of pain and anxiety with morphine sulfate (or fentanyl if systolic pressure is compromised) can reduce excessive sympathetic activity and decrease oxygen demand, preload, and afterload.

Anti arrhythmic
Arrhythmia and heart block may substantially affect cardiac output and should be corrected promptly with antiarrhythmic drugs, cardioversion, or pacing. Cardiology consultation has been shown to be associated with improved outcomes in patients with myocardial infarction and is strongly indicated in the setting of cardiogenic shock.

Inotropes
In patients with inadequate tissue perfusion and adequate intravascular volume, cardiovascular support with inotropic agents should be initiated.

Dobutamine, a selective β1-adrenergic receptor agonist (Dose 5-20µg/kg/min), can improve myocardial contractility and increase cardiac output without markedly changing heart rate or systemic vascular resistance; it is the initial agent of choice in patients with systolic pressures greater than 80 mm Hg. Dobutamine may exacerbate hypotension in some patients and can precipitate tachyarrhythmia especially when used in higher doses.

Dopamine acts directly on myocardial β1-adrenergic receptors (Dose 5-10µg/kg/min) and acts indirectly by releasing norepinephrine. It has both inotropic and vasopressor effects, and its use is preferable in the presence of systolic pressures less than 80 mm Hg. Tachycardia and increased peripheral resistance with dopamine administration may exacerbate myocardial ischemia. In some situations, a combination of dopamine and dobutamine can be more effective than either agent alone.

When hypotension remains refractory, norepinephrine — a natural catecholamine with potent α and β1-adrenergic effects (2-8µg/min) — may be necessary to maintain organ perfusion pressure. Catecholamine infusions must be carefully titrated in patients with cardiogenic shock to maximize coronary perfusion pressure with the least possible increase in myocardial oxygen demand.

Adrenaline a potent stimulator of β1, β2 receptors and α receptors (dose 2-8µg/min) may be helpful in desperate situations when other inotropes are not helpful.

Invasive hemodynamic monitoring can be extremely useful in allowing optimization of therapy in these unstable patients because clinical estimates of filling pressure can be unreliable; in addition, changes in myocardial performance, compliance, and therapeutic interventions can change cardiac output and filling pressures precipitously. Optimization of filling pressures and serial measurements of cardiac output (and other measures, such as mixed venous oxygen saturation) allow titration of the dosage of inotropic agents and vasopressors to the minimum dosage required to achieve the chosen therapeutic goals. This minimizes the increases in myocardial oxygen demand and arrhythmogenic potential.
The phosphodiesterase inhibitors amrinone and milrinone have positive inotropic and vasodilatory actions. They have long half-lives and may cause hypotension and thrombocytopenia; therefore, they are reserved for use only when other agents have proven ineffective. Because they do not stimulate adrenergic receptors directly, they may be effective when added to catecholamines or when β-adrenergic receptors have been downregulated. Compared with catecholamines, phosphodiesterase inhibitors have minimal chronotropic and arrhythmogenic effects.

Diuretics should be used to treat pulmonary congestion and enhance oxygenation. Furosemide is drug of choice used in doses of 20-80 mg intravenous boluses. The frequency of administration should be decided by pulmonary congestive states preferably guided by PCWP measurements, to be maintained below 25 mm Hg.

Vasodilators should be used with extreme caution in the acute setting because of the risk for precipitating further hypotension and decreasing coronary blood ow. After blood pressure has been stabilized, however, vasodilator therapy can decrease both preload and afterload. Sodium nitroprusside is a balanced arterial and venous vasodilator that decreases filling pressures and can increase stroke volume in patients with heart failure by reducing afterload (dose 0.5-8 µg/kg/min).

Nitroglycerin is an effective venodilator that reduces the pulmonary capillary occlusion pressure and can decrease ischemia by reducing left ventricular filling pressure and redistributing coronary blood ow to the ischemic zone (dose 5 –50 µg/kg/min). Both agents may cause acute and rapid decreases in blood pressure, and dosages must be titrated carefully; invasive hemodynamic monitoring can be useful in optimizing filling pressures when these agents are used.

In addition, medications proven to improve outcome after myocardial infarction, such as nitrates, β1-blockers, and angiotensin-converting enzyme inhibitors, may exacerbate hypotension in a patient with cardiogenic shock; therefore, therapy with these medications should be discontinued until the patient stabilizes.

Intra aortic balloon counterpulsation

Intra-aortic balloon counterpulsation is valuable for stabilising patients with cardiogenic shock and may improve the efficacy of thrombolytic agents. It increases diastolic coronary arterial perfusion and decreases systemic afterload without increasing myocardial oxygen demand. Few data are available to support its use in improving outcomes of patients with shock; however, preliminary data have shown that it might be beneficial in conjunction with revascularisation hence it is worthwhile using IABP early in the course of treatment rather than delayed once hypotension is persistent with evidence of tissue hypoxia. Anderson and colleagues reported that intra-aortic balloon counterpulsation used primarily as an adjunctive treatment to revascularisation in the GUSTO-I trial was associated with a trend towards lower 30-day and 1-year mortality rates.

The combination of a coherent scientific rationale combined with these encouraging studies made this a promising avenue of investigation, and the publication of the randomized TACTICS (Thrombolysis And Counterpulsation To Improve Cardiogenic Shock Survival) I trial was eagerly awaited. Unfortunately, this has now been abandoned due to poor recruitment, and the role of balloon-assisted thrombolysis in the management of shock remains undefined.

In hospitals without direct angioplasty capability, stabilization with IABP and thrombolysis followed by transfer to a tertiary care facility may be the best management option. Intra-aortic balloon pumping may be a useful adjunct to thrombolysis in this setting by increasing drug delivery to the thrombus, improving coronary ow to other regions, preventing hypotensive events, or supporting ventricular function until areas of stunned myocardium can recover.

A variant on this theme is the use of inotropes to increase the blood pressure transiently to a point at which thrombolysis might be effective. This is potentially a more logical use of inotropes than our
current practice, and is supported by evidence from a canine model. To date, this has only been investigated in a small series of eight patients, of whom reperfusion was demonstrated in six, and the role of this approach must await further studies.

Reperfusion Strategies in Cardiogenic Shock Complicating Acute Coronary Syndromes
The outcome of cardiogenic shock is closely linked to the patency of the culprit coronary arteries. Accordingly, reperfusion therapy with thrombolytic agents has decreased the occurrence of shock among patients with persistent ST-segment-elevation myocardial infarction. The GUSTO-I experience indicated that tissue-plasminogen activator is more efficacious than streptokinase in preventing shock.

Thrombolytic Therapy
Thrombolytic therapy for patients who have already developed shock has been very disappointing. The Gruppo Italiano per lo Studio della Streptochinasi nell’ Infarto miocardico (GISSI-I) study, which compared patients receiving streptokinase with a control group, included patients with cardiogenic shock: 69.9% of the 146 patients who presented with shock and received streptokinase died within 21 days, compared with 70.1% of the 134 shock patients in the control group. Once shock develops, streptokinase may be slightly more effective than tissue plasminogen activator, perhaps by decreasing afterload, whereas tissue plasminogen activator and reteplase are similarly effective. The lack of benefit of thrombolytic agents in treating cardiogenic shock may be attributed to decreased coronary thrombolyis in states of low perfusion pressure.

The reasons for decreased thrombolytic efficacy in patients with cardiogenic shock are not fully understood but probably include hemodynamic, mechanical, and metabolic factors. Decreased arterial pressure limits the penetration of thrombolytic agents into a thrombus. Passive collapse of the infarct artery in the setting of hypotension can also contribute to decreased thrombolytic efficacy, as can acidosis, which inhibits the conversion of plasminogen to plasmin.

Revascularisation
Reestablishment of brisk (TIMI [Thrombolysis in Myocardial Infarction] grade 3) ow in the infarct related artery is an important determinant of left ventricular function and survival after myocardial infarction. Direct percutaneous transluminal coronary angioplasty (PTCA) can achieve TIMI grade 3 ow in 80% to 90% of patients with myocardial infarction, compared with rates of 50% to 60%, 90 minutes after thrombolytic therapy. In the Primary Angioplasty in Myocardial Infarction (PAMI) trial, which compared direct angioplasty with thrombolytic therapy, a mortality benefit for PTCA (in-hospital mortality rate, 2.0% compared with 10.4%; P < 0.01) was seen in high-risk patients (age >70 years, large anterior myocardial infarction, heart rate >100 beats/min). Therefore, patients with cardiogenic shock are candidates for direct angioplasty. In addition to improving wall motion in the infarct territory, increased perfusion of the infarct zone has been associated with augmented contraction of remote myocardium, possibly caused by recruitment of collateral blood ow.

Pathophysiologic considerations and extensive retrospective data favor aggressive mechanical revascularization for patients with cardiogenic shock caused by myocardial infarction. Recently, a landmark study (the SHOCK trial ) presented data from a randomized,controlled trial. In this trial, 302 patients with ST elevation were randomized within 36 h of infarction and within 18 h of the onset of shock. Strictly speaking, the comparison was between immediate revascularization (of which 64% was by PTCA) and revascularization preceded by a period of medical management (21% of patients in this latter group were subsequently revascularized). Mortality was not significantly different between the two groups at the primary end point of 30 days (47% vs. 56%), but reduced the secondary end-points at 6 months (50% vs. 63%, p<0.03) and 1 year (53% vs. 66%, p<0.03).
Role of Gp IIb/IIIa Antagonists in Cardiogenic Shock

The role of adjunctive antiplatelet therapy is also evolving. Platelet glycoprotein IIb/IIIa antagonists have been shown to improve short-term clinical outcomes after angioplasty, especially in patients at high risk for complications. Published experience with IIb/IIIa receptor inhibition in patients with cardiogenic shock is thus far limited to case reports but extrapolation from other settings suggests that they may play an important adjunctive role in patients with shock who undergo angioplasty.

CABG

Many trials have reported favorable outcomes for patients with cardiogenic shock who have coronary artery bypass surgery. Left main and three-vessel coronary disease are common in patients with cardiogenic shock, and the potential contribution of ischemia in the noninfarct zone to myocardial dysfunction in patients with shock would support complete revascularization. Nonetheless, the logistic and time considerations involved in mobilizing an operating team, the high surgical morbidity and mortality rates, and the generally favorable results of percutaneous interventions discourage routine bypass surgery for these patients.

Current Recommendations

The preferred treatment is PCI of the IRA for patients with 1- to 2-vessel coronary artery disease (CAD) and suitable lesions. Moderate 3-vessel disease, ie, 100% IRA occlusion, 90% stenosis in 2 other major vessels, or more severe lesions in second order vessels, may be treated with PCI of the IRA and staged complete revascularization, as indicated. Routine use of Glycoprotein IIb/IIIa antagonists and stents is recommended. Immediate CABG is the preferred treatment for selected severe 3-vessel or left main CAD. If CABG cannot be performed, single-vessel or multivessel PCI may be attempted. Distal embolization in the non–IRA territories during PCI may be disproportionately harmful in the setting of shock or recent shock. Therefore, CABG is generally preferred to PCI when revascularization of the non–IRA artery is clinically indicated in the week after shock. However, early multivessel PCI may be warranted when shock persists despite PCI of the IRA, when CABG cannot be performed.

The role of newer thrombus extraction and distal protection devices in the setting of large thrombus burden during PCI, in shock state appears to be promising, but needs further evaluation.

Indian Scenario

Management in our country will vary depending on the available team of experts and cath lab facilities:

a) When trained qualified personals and lab facilities are available, this strategy comprises of a very quick diagnostic workup with hemodynamic stabilization with inotropes and IABP along with all supportive measures and immediate transfer to a cath lab for early angiography and angioplasty with GpIIb IIIa antagonists and stenting.

b) In the centers without cath lab facilities : the best option is inotropic hemodynamic stabilization (+ Early use of IABP if available) with thrombolysis without delay and transfer to a center with angio lab facilities at the earliest possible.

Specific Conditions

Right Ventricular Infarction

Right ventricular infarction occurs in up to 30% of patients with inferior infarction and is clinically significant in 10%. Patients present with hypotension, elevated neck veins, and clear lung fields. Diagnosis is made by identifying ST-segment elevation in right precordial leads or characteristic hemodynamic findings on right-heart catheterization (elevated right atrial and right ventricular end-diastolic pressures with normal to low pulmonary artery occlusion pressure and low cardiac output). Echocardiography can
show depressed right ventricular contractility with RV free wall motion abnormalities and low pressure TR. Patients with cardiogenic shock on the basis of right ventricular infarction have a better prognosis than those with left-sided pump failure. This may be due in part to the fact that right ventricular function tends to return to normal over time with supportive therapy, although such therapy may need to be prolonged. Supportive therapy for patients with right ventricular infarction begins with maintenance of right ventricular preload with fluid administration preferably guided by invasive hemodynamic monitoring. In some cases, however, fluid resuscitation may increase pulmonary capillary occlusion pressure but may not increase cardiac output, and overdilation of the right ventricle can compromise left ventricular filling and cardiac output. Inotropic therapy with dobutamine may be more effective in increasing cardiac output in some patients with adequate filling pressures, and monitoring with serial echocardiography may also be useful to detect right ventricular overdistention. Maintenance of atrioventricular synchrony is also important in these patients to optimize right ventricular filling which can be achieved with drugs such as atropine or by temporary dual chamber pacing.

For patients with continued hemodynamic instability, intra-aortic balloon pumping may be useful, particularly because elevated right ventricular pressures and volumes increase wall stress and oxygen consumption and decrease right coronary perfusion pressure, exacerbating right ventricular ischemia. Reperfusion of the occluded coronary artery is also very crucial and it is worthwhile carrying angiography and PTCA to occluded RCA.

**Acute Mitral Regurgitation**

Ischemic mitral regurgitation is usually associated with inferior myocardial infarction and ischemia or infarction of the posterior papillary muscle, which has a single blood supply (usually from the posterior descending branch of a dominant right coronary artery). Papillary muscle rupture usually occurs 2 to 7 days after acute myocardial infarction; it presents dramatically with pulmonary edema, hypotension, and cardiogenic shock. When a papillary muscle ruptures, the murmur of acute mitral regurgitation may be limited to early systole because of rapid equalization of pressures in the left atrium and left ventricle. More important, the murmur may be soft or inaudible, especially when cardiac output is low.

Echocardiography is extremely useful in the differential diagnosis, which includes free-wall rupture, ventricular septal rupture, and infarction extension pump failure. Hemodynamic monitoring with pulmonary artery catheterization may also be helpful.

Management includes afterload reduction with nitroprusside and intra-aortic balloon pumping as temporizing measures. Inotropic or vasopressor therapy may also be needed to support cardiac output and blood pressure. Definitive therapy, however, is surgical valve repair or replacement, which should be undertaken as soon as possible because clinical deterioration can be sudden even though surgical mortality is known to be high.

**Ventricular Septal Rupture**

Patients who have ventricular septal rupture have severe heart failure or cardiogenic shock, with a pansystolic murmur and a parasternal thrill. The classic finding is a left-to-right intracardiac shunt (a “stepup” in oxygen saturation from right atrium to right ventricle and PA). On pulmonary artery occlusion pressure tracing, ventricular septal rupture can be difficult to distinguish from mitral regurgitation because both can produce dramatic “V” waves. The diagnosis is most easily made with echocardiography. Rapid stabilization—using intra-aortic balloon pumping and pharmacologic measures—followed by surgical repair is the only viable option for long term survival. The timing of surgery is controversial, but most experts now suggest that operative repair should be done early, within 48 hours of the rupture. Recently, however, some workers have closed such acquired VSDs with the devices, percutaneously with encouraging results, though long term results are still unknown.
Free-Wall Rupture
Ventricular free-wall rupture usually occurs during the first week after myocardial infarction; the classic patient is elderly, hypertensive, female. The early use of thrombolytic therapy reduces the incidence of cardiac rupture, but late use may increase the risk. Free-wall rupture presents as a catastrophic event with a pulseless rhythm. Salvage is possible with prompt recognition, pericardiocentesis to relieve acute tamponade, and thoracotomy with repair which is rather rare.

Reversible Myocardial Dysfunction
In addition to hibernating and stunned myocardium, potentially reversible causes of myocardial dysfunction include sepsis-associated myocardial depression, myocardial dysfunction after cardiopulmonary bypass, and in ammatory myocarditis. In sepsis and, to some extent, in myocarditis, myocardial dysfunction seems to result from the effects of in ammatory cytokines, such as tumor necrosis factor and interleukin-1. Myocardial dysfunction can be self-limited or fulminant, with severe congestive heart failure and cardiogenic shock. In the latter situation, cardiovascular support with a combination of inotropic agents (such as dopamine, dobutamine, or milrinone) and IABP may be required for hours or days to allow sufficient time for recovery. If these measures fail, mechanical circulatory support with left ventricular assist devices can be considered. These devices can be used as a bridge to cardiac transplantation in eligible patients or as a bridge to myocardial recovery; functional improvement with such support can be dramatic.

Newer Therapies
Attempts to improve the myocardial salvage has been centered on reducing neutrophil and platelet migration/adhesion whilst maximizing ischemic tolerance of the myocyte.

Various agents tried are Na+H+ exchanger inhibitors – These class of drugs have given con icting results. Initial results in patients undergoing primary PTCA showed improved LV function, but no benefit was found in large unselected group of patients in the GUARDIAN trial. NG-monomethyl-L-arginine (L-NMMA), an antagonist of nitric oxide synthase, has been studied in a small pilot study of 11 patients with persistent cardiogenic shock. All patients were on IABP, mechanical ventilation, and large doses of vasopressors. Administration of bolus and infusion of L-NMMA resulted in sustained improvement in arterial pressure and urine output. Ten of the 11 patients could be weaned from mechanical ventilation and IABP, and seven were dismissed home and werealive at a 1–3-month follow up. This approach is currently under evaluation for a large, multicenter, randomized clinical trial.

Summary
Commonest cause for cardiogenic shock remains to be large AMI. Mortality rates in patients with cardiogenic shock remain frustratingly high (50% to 80%). The pathophysiology of shock involves a downward spiral: ischemia causes myocardial dysfunction, which in turn worsens ischemia. Areas of nonfunctional but viable myocardium can also cause or contribute to the development of cardiogenic shock. The key to a good outcome is an organized approach with rapid diagnosis and prompt initiation of therapy to maintain blood pressure and cardiac output. Expeditious coronary revascularization is crucial. When available, emergency cardiac catheterization and revascularization with angioplasty or coronary surgery seem to improve survival and represent standard therapy at this time. In hospitals without direct angioplasty capability, stabilization with IABP and thrombolysis followed by transfer to a tertiary care facility may be the best option.

References