The High Mortality Among Patients in Cardiogenic Shock “LV or RV Infarcts” — What Have We Learned and Have We Made a Difference?

In this symposium, we will revisit the treatment of cardiogenic shock complicating acute myocardial infarction with both right ventricular and left ventricular problems. In patients who do not survive cardiogenic shock complicating acute myocardial infarctions, a number of well known univariate predictors have stood up over time: Age greater than 60 years, prior angioplasty, the use of intraaortic balloon pumps (trends) and early revascularization. (Edep and Brown Am J Cardiol 2000;85:1185–1188).

Right ventricular infarction is a common cause of cardiogenic shock among patients with ST segment elevation myocardial infarction. It accounted for 20% of cases involving shock in the GUSTO I trial. These problems comprised the volume sensitive state that contrasts with the pressure sensitive state characteristic of predominantly left ventricular infarcts. (Lancet 2000;356:749–755).

We will discuss the revascularization techniques in cardiogenic shock including angioplasty, stents, coronary artery bypass, (on and off the pump), and selective valve or ventricular septal defect repair. Mortality has declined for patients greater than 65 years of age complicated by cardiogenic shock. We feel that this has occurred in the setting of broader use of early revascularization and adjuncts to medical therapy for this high-risk population.

Intraaortic balloon pump use in cardiogenic shock has shown survival advantage, but there are no good randomized trials and the effect of additional factors is not clear, including selection timing, direct revascularization strategies, thrombolytics, etc. The SHOCK trial has given us a great deal of information about the importance of our approach to patient with shock in acute myocardial infarction. We will discuss these in some detail and review the data from the SHOCK trial. (Barr, Chou in Am Heart J 2000;141:133–139 and Webb, Hochman et al. Am Heart J 2001;141:964–970).

The trends in outcomes are that early revascularization may be associated with a significant reduction in in-hospital mortality compared to the patients that are treated less aggressively. The widespread use of intracoronary stents and antiplatelet agents appear to help with the early hazards of shock complicating acute myocardial infarction.

Our recommendations in treatment of these patients will be reviewed and supported by the discussion from the panel. We are guardedly optimistic about improvement and the outcomes of this critically ill population.

Paul A. Overlie, MD, FACC, FACP

Moderator: James P. Zidar
Panel Members: Luis de la Fuente; Gian Feltrin; Alfredo Rodriguez; and Fayaz Shawl

Fayaz Shawl: Since we are more aggressive early on, the number of shock cases has diminished. In terms of our approach in treating cardiogenic shock cases, it really depends on the patient’s overall status. Most cardiogenic shock cases I see today are not as extreme as in the past because they present for earlier treatment. For patients in cardiogenic shock — I mean true shock which is associated with low blood pressure and signs of hypoperfusion — we routinely place a balloon pump. I and others have reported on the use of IABP, which is probably the most common type of support used. The number of patients requiring CPS is very small — only two or three cases a year at my hospital. These cases involve patients who are in full-blown shock, and the majority of them have multi-vessel coronary disease. As we have seen from Paul Overlie’s work and that of others, if we just perform infarct-related vessel intervention on the multi-vessel disease patients, there is a much higher incidence of mortality. At our lab, if we find that the other two vessels have very tight lesions, especially with a reduction of TIMI flow, we will not only treat the infarct-related vessel, but will intervene on the other two lesions as well, producing much better outcomes. In summary, the number of shock patients is fairly small, and the majority of them are successfully treated with intervention and sometimes balloon pump therapy. A very small percentage of patients require more support such as CPS.

James P. Zidar: Are there any comments from our Argentine colleagues? Dr. de la Fuente?

Alfredo Rodriguez: In terms of performing intervention on patients in cardiogenic shock, we see some issues that need resolving. First, patients need early intervention. In the SHOCK trial, for instance, when we evaluated the results, the time period from diagnosis...
of shock, to randomization, to opening the artery, was too long. The use of intra-aortic balloon pumps is another important issue, as is the use of glycoprotein IIb/IIIa agents. One of the major problems with the acute myocardial infarction trials, ADMIRAL and CADILLAC, which tested the use of IIb/IIIa glycoproteins in the acute MI site, is the selection bias. Cardiogenic shock is one of the exclusion criteria in these trials. Thus, with these trials, we cannot evaluate the role of IIb/IIIa glycoprotein agents in treating cardiogenic shock. Perhaps we need a more realistic trial that includes patients in a real world presentation of acute myocardial infarction to evaluate IIb/IIIa glycoproteins.

We are currently involved in a trial, which also includes institutions in Germany and Italy, to test the role of stents and IIb/IIIa agents in patients in the real world presentation of in acute myocardial infarction. The data from this trial, called ACE, will be available soon. The ACE trial includes 17% of patients with cardiogenic shock of TIMI 3, 70% of whom have been treated for for PCA in acute myocardial infarction. The interim analysis of this trial seems to show that the use of glycoprotein IIb/IIIa inhibitors have benefitted in patients with TIMI 3–TIMI 4 flow, treated with intervention. Of course, I think that complete revascularization is an important issue for patients in cardiogenic shock. We try to revascularize the patient completely if possible, even with PCI.

Luis de la Fuente: As one of the oldest cardiologists here, I have enjoyed hearing so much of the history of Interventional Cardiology this morning. Most of the treatment modalities for cardiogenic shock have already been discussed today and I also absolutely agree that the patient in cardiogenic shock must be treated as soon as possible to open the occluded artery in the case of an acute myocardial infarction.

I would like to comment on how we see cardiogenic shock from the South. First of all, allow me to review some history that may explain why we don’t see as much cardiogenic shock in Argentina. With Favaloro, going back to 1969, we were convinced that myocardial revascularization was a very good procedure to improve blood flow to the ischemic heart, and the problem for us from then on would be the treatment of the acute coronary syndromes, especially the acute myocardial infarction and its complications.

When we returned to Argentina from the U.S. in January 1970, we performed the first coronary angiography without any complications in 5 patients with acute myocardial infarction showing that this procedure was safe and feasible. In 1971, Favaloro wrote a book on myocardial revascularization and he said that one day acute myocardial infarction would be treated the same way that we were treating a “dead leg” — that is, given oxygenated blood to the infarcted area. However, at that time there was a good deal of pathological work in animals, primarily in dogs, showing that if oxygenated blood was given to an acute myocardial infarction area in the first hours, you would transform an anemic infarction into an hemorrhagic one and it would be very deleterious. We did not agree with this concept. On the contrary, we thought that monkey hearts would be more like our hearts.

In 1972, we conducted studies in monkeys, ligating the left anterior descending artery and releasing the ligature after 6 hours and we could prove by left ventricular cineangiography that the left ventricular function improved dramatically after we released the ligature. Our studies showed that if we could revascularize the infarcted area in the first 6 hours, we could diminish the size of the infarct. From then on we started doing bypass surgery in acute myocardial infarction.

Our work was presented at the American College of Cardiology meetings and was seen with enthusiasm by some doctors and with a lot of skepticism and criticism by others. We were invited to publish our experience, but our manuscripts were rejected by the reviewers, saying that the coronary and left ventriculogram pre and post were beautiful but that we were crazy. That is enough for the history. Years went by and physicians in Argentina gradually became educated on what to do when a patient with an acute myocardial infarction develops angina pectoris and/or continues to have ischemic changes either by EKG or Holter. It became evident that these patients could have an extension of the infarct or a new infarct in a different territory and they should be studied by angiography immediately.

They also learned that in about 40% of the patients the first manifestation of coronary artery disease is an acute myocardial infarction or sudden death. If a patient has angina pectoris or others signs and/or symptoms of myocardial ischemia he has a real advantage because he can consult his cardiologist before any serious event.
We stressed to the cardiologist that when a patient has an infarcted ventricular mass of near 40% he will go into cardiogenic shock and his prognosis will be very poor. We also told them that a patient with single vessel disease does not always have a relatively good prognosis. It is very important to know, not only the severity of the lesion and type of plaque, but also the location, the size of the artery and the absence or presence of adequate collateral circulation. A large left anterior descending artery can irrigate up to 33% of the left ventricular mass, very close to the 38–40% necessary to produce a cardiogenic shock.

In our experience with acute myocardial infarction complicated by a severe mitral regurgitation produced by the rupture of the posterior papillary muscle, close to 25% of these patients had either a very large superdominant right coronary or circumflex artery. These patients can also go into cardiogenic shock.

In conclusion, I would say that the best treatment for cardiogenic shock is its prevention. Perhaps that is why, in Argentina, we currently don’t see many patients in cardiogenic shock. However when we do see a patient with acute myocardial infarction in true cardiogenic shock we act more or less in the same way that Dr. Shawl has outlined. We also agree that there must be an cardiac interventionist on call 24 hours a day.

James Zidar: Thank you for those comments. How about what’s going on in Italy? Are there any differences in the approaches you use?

Gian Feltrin: We basically use the same approach. In northern Italy, we have the benefit now of a new public health system in which a patient can be transported to the hospital or moved to another facility very quickly. The territories are divided according to emergency specialties in many centers, the system (Phone M8) constitutes one of the most important changes implemented in Italy in the past five or six years.

Secondly, there has been a significant drop in the number of cardiogenic shock patients — less than 5% of patients seen. Also, our operators frequently use intra-aortic balloon pump devices as well as counterpulsation because these devices allow for more prompt intraarterial intervention. Thus, we can achieve rapid reperfusion and even potentially restrict the infarction.

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James Zidar: I have two questions. First, do any of you have age criterion cut-offs? Paul, you alluded to the age factor when you mentioned that elderly patients above the age of 75 in cardiogenic shock have quite a high mortality rate. Do you treat everybody in your practices, or do you say, “Gee, the patient is over the age of 80 and is in shock; I’m not going to go to the trouble.”

Fayaz Shawl: In my practice, if a patient is in cardiogenic shock, I don’t concern myself with his or her age, I just do the job.

Paul Overlie: If there are specific family requests not to, we don’t. But generally we do, because one of the reasons we take patients to the cath lab and support them with a balloon pump is to determine exactly what the anatomy is and to risk stratify them for things that may occur downstream.

Alfredo Rodriguez: Age is a risk factor for PCI and primary PTCA, independent of whether the patient is in cardiogenic shock or not. There is an ongoing trial — the SINIO-PAMI trial — which is attempting to answer the question about what the role of PCI is in older age. In patients in cardiogenic shock, I think we have to prioritize the shock over the age. In our practice, if a patient is in shock, regardless of age, we will attempt to do something.

Luis de la Fuente: When we see patients in cardiogenic shock — especially women over 60 years of age — we have to rule out severe mitral regurgitation produced by a rupture of the papillary muscle. There is a high incidence of single-vessel disease in this group of patients.

James Zidar: We actually have three hospitals that refer patients to our institution. These hospitals, which use Duke as a back-up center, have diagnostic labs, two of which are equipped for interventional procedures. If a patient comes in with an acute myocardial infarction and is stable, these hospitals will often hang on to the patient. But if the patient comes in with shock, they will usually put a balloon pump in and transport the patient to our facility. Dr. Magnus Ohman, who was at Duke for a long time and who is now at UNC in Chapel Hill, was trying to initiate a local balloon pump trial with the goal of getting local emergency room doctors to put balloon pumps in and then transport the patient to a center for angioplasty. One of the struggles Dr. Ohman encountered was that the physicians who are most comfortable putting in balloon pumps are interventional cardiologists who perform a lot of cases and handle a lot of sick patients, not the physician who does an

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I must emphasize that at our centers, the use of these devices is very consistent, as seen in the literature. I don’t have hard data available, but I do know that these devices are widely used because cardiologists, cardiac surgeons and other practitioners can rather easily deploy them. With intra-aortic pump, we obtain an effective aid to the blood flow, and also, we offer a useful opportunity to coronary revascularization. On the other hand, in sudden failure, after surgery the intra-aortic balloon pumps are very effective and can greatly improve outcomes.
occasional case or does it without surgical back-up. It was thus difficult for Dr. Ohman to recruit patients.

Would anyone in the audience or on the panel like to comment on how you handle a patient who presents in cardiogenic shock to a hospital located an hour from your facility?

Paul Overlie: We used to fly over and put the balloon pumps in the patients ourselves. We don’t do that as often anymore due to fatigue, I suppose. Now we put the patients on pressors and transport them to our facility as quickly as possible.

James P. Zidar: So you’re not having someone put the balloon pump in at the local emergency room?

Paul Overlie: No. It’s under discussion again, but we haven’t instituted it yet.

Gian Feltrin: In Italy, we have had extensive experience with thrombolytic therapy. One of the trials, called GISSI, studied streptokinase use. The results we obtained, however, were not convincing. If the thrombolytic, administered by rapid intra-arterial infusion, is used with the support of an intra-aortic balloon pump, the results are favorable. We have noted a reduction in mortality in normal terms.

Kirk Garratt: We have been in the practice of encouraging our referring physicians within the Mayo Clinic healthcare system to send the patients promptly to us in order to get a balloon pump in place. As described earlier, we have a couple of hospitals that are now equipped and staffed to perform angioplasty on-site without surgical support. In those hospitals, we have made a decision to pull out all the stops: we will use aggressive therapies to treat patients and this includes using the intra-aortic balloon pump. The present challenge at those facilities is how to manage vascular complications among those patients, because hospitals that cannot support a cardiac surgeon usually will have difficulty supporting a vascular surgeon as well. General surgeons can do some vascular work, but they are usually not very enthusiastic about managing your gigantic retroperitoneal hematoma at 2:00 am. The published complication rates with IABP still hover between 10–15%. I think the SHOCK data from Judith Hochman’s study are very good. Good medical therapy with intra-aortic balloon pump therapy will provide life-saving treatment for the majority of patients and may rival what we can do for those patients when we take them to the cath lab. I also think that, at least in North America, most hospitals that cannot offer catheter therapy will also have a very difficult time offering safe and effective balloon pump therapy.

James Zidar: For the sites that perform angioplasty, with Mayo Clinic backing them up, are they performing acute angioplasty with balloon pump on shock patients as well?

Kirk Garratt: Yes. Those hospitals do handle “all comers.” However, we are still maintaining an expedited transport system for the shock patients. This is not done because of balloon pump concerns necessarily — which are very real — but simply because some of those patients will be in cardiogenic shock due to a blown out mitral valve or a VSD, or something requiring surgery. We do take these patients to the cath lab early so we can open up any occluded vessels that may need therapy.

Paul Overlie: We actually instituted a similar program in the early- to mid-1980s with a center north of us where they placed the balloon pump, but the patient was brought back to the home hospital. I still feel better about that arrangement because those patients are extremely sick. All a smaller hospital needs is to have a couple of those patients die and its programs could be in jeopardy.

Jeff Werner: I have a question for Dr. Shawl. I believe you said that you think patients should be completely revascularized during acute infarction using angioplasty and stenting. I have not been doing that, however. If patients who come in with lactic acidosis and arrhythmias turn around quickly when I open the target artery, I think they ought to have a breather, so I take the patient back upstairs and wait a while. Some of these patients also have multi-vessel disease for which the best outcome might be surgery, depending on the anatomy. If I’m wrong, I would like to know what you think I should be doing instead.

Fayaz Shawl: Most of the data from the SHOCK trial regarding multi-vessel coronary disease patients with shock show that intervening solely on the infarct-related vessel results in a mortality rate of about 60–70%. Part of the reasoning is that if, for instance, a patient presents with acute myocardial infarction, the LAD is totally occluded, the sub-total circumflex is critical, then a non-infarct area may be important for the patient’s outcome. Given that information, I definitely try to completely revascularize patients with multi-vessel disease. If this is not possible, then I send the patient to surgery.

Jeff Werner: Even if the patient improves as soon as you open up the infarct-related artery, the blood pressure is normal, the EKG normalizes, etc.?

Fayaz Shawl: I think it does depend on the situation. I’m talking about complete revascularization for patients who are critical: blood pressure is 70, a balloon pump is in place, the patient is on epinephrine, etc. In those cases, I do everything in the lab that I can to revascularize the patient. However, if there are three occluded vessels, but the patient’s blood pressure and other signs normalize after just opening the infarct-
related vessel, then I would not attempt complete revascularization at that time.

Paul Overlie: Gregg Stone has looked at a large number of series on that particular issue. If the patients are still “shocky,” then it is recommended that you proceed to treat the other vessels. But if the patient rapidly recovers, you should stop after opening the target vessel.

An even more difficult treatment category, but one we ought to explore further, is more widespread use of hemodynamic support. Dr. Magnus Ohman looked at the anterior infarct problems for the PAMI 2 trial. Those in the high-risk limb had balloon pump versus no balloon pump, and there really wasn’t any survival advantage even though patients tended to need fewer trips back to the cath lab when an intra-aortic balloon pump was used. Thus the balloon pump patients in the PAMI 2 trial were not quite in shock, but did show high-risk anatomy such as triple-vessel disease, diabetes, female gender, etc.

Many of us face the problem of the patient who has a giant occluded right coronary artery with a 70% left main lesion. The patient is not shocky but when we open the RCA and perform angioplasty and stenting, I bet the majority of us will leave a balloon pump in place in these patients. I may send that patient to surgery if there is a left main lesion, but I want to give that patient “a ride on the balloon pump” to ensure he remains stable. Sometimes we can open that RCA rapidly, and the patient ends up with normal ventricular function. There are just so many variables in the use of hemodynamic support — and if the patient isn’t “shocky,” I still think IABP is valuable in a true shock patient without revascularization, however, I don’t think IABP is very beneficial.

Fayaz Shawl: We have all seen patients in extreme shock with a Swan Ganz in place, inotropes are administered, and they have reduced capillary pressure. Even if you totally revascularize these patients, they may still be “shocky.” These patients present the biggest challenge in terms of post-shock management. We may intubate them — which I think is very important — when their oxygen saturation is only 70–80%. Also, there is a subset of patients who have very poor left ventricular function; they have very high LVDP, they are intubated, and may need some type of support, even if revascularization was performed. This may involve either CPS or LVADs because these patients may need more prolonged support after the revascularization to improve their outcomes.

Gian Feltrin: I would like to make a point about what can be expected in the future in the area of imaging as a support to cardiogenic shock or to possibly prevent its occurrence in the first place. Unfortunately, our institution does not have nuclear or magnetic resonance imaging equipment near the cardiac center. It is therefore difficult to gain any advantages from that type of imaging support. On the contrary, at the newer center, a nuclear medicine department devoted to this has ameliorated a large number of stroke problems. Good imaging is very important in stroke intervention because nuclear and MRI tests provide valuable information for treatment strategies. I think that in the future, these diagnostic modalities will play a valuable role, even in cardiac treatment areas.

Howard Cohen: I would like to present a different approach that we have been taking with patients in cardiogenic shock. I had a patient who was referred to me at about 3:00 pm on a Friday. The patient was in cardiogenic shock with shortness of breath, moderate CK leak, and was thought to have aortic stenosis. This patient had prior bypass surgery. The referring physician asked if we could perform aortic valvuloplasty on the patient. I told him that we didn’t perform that procedure very often anymore, but said I would take a look at the patient. The patient obviously had very severe mitral regurgitation and also had fairly significant aortic valve disease and aortic stenosis. When in cardiogenic shock, the patient’s PA saturation was about 45% and his Ph about 7.07, so he was really in the tank. The question was: What should we do? The surgeons obviously were not anxious to take this patient, given his condition and history of bypass surgery. By the way, the patient’s coronary arteries showed that he had severe three-vessel disease, but did have a patent LIMA.

The first question was: What advantage would an intra-aortic balloon pump provide in this case? In my estimation, IABP would offer little benefit because the patient had a fixed obstruction at the aortic valve and a balloon pump wouldn’t do much for mitral regurgitation. We placed a large transseptal catheter in the patient’s left atrium and took the flow from the left atrium and reinfused it with a centrifugal pump that sits on the leg (about half the size of a coffee cup), with approximately 4 liters of flow. Thus, it is taking all the left atrial flow, all that mitral regurgitation, and now making it forward cardiac output. In the cath lab, the patient’s PA saturation rose to 68% and really turned around. We put the patient in the coronary care unit, tuned him up and ultimately sent him on to surgery.

Paul Overlie: That’s a good point, Howard, in cases where there is potential for recovery. In earlier
years, we would rescue patients from cardiac arrest and find out there was nothing to rescue. But if the patient can rest and improve, I think that approach offers a definite advantage.

Howard Cohen: We use a large 21 Fr cannula placed over an Inoue wire. This transseptal catheter will take the blood from the left atrium through the pump and reinfuse the femoral artery. We looked at flow in the descending aorta to see how much the pump contributed to systemic blood flow. Many people said: “This thing is in the femoral artery, really perfusing the brain.” We looked at retrograde and antegrade flow. With the pump turned on at one liter per minute, there is not much retrograde flow—it’s mostly antegrade flow. When the tandem heart was turned on to 2 liters of flow, we achieved more retrograde flow. There is also a very narrow spike of systolic flow in the aorta. But as we increase to 3.5 liters per minute, a broad continuous antegrade flow is evident. There is continuous flow in the descending aorta and good reperfusion in the systemic circulation. When the flow is increased; there is more continuous flow, more diastolic flow in the carotid artery, so the brain is definitely perfused.

Very interestingly, the patient I am describing here went to surgery, had aortic valve replacement, mitral valve repair and triple-vessel bypass. The assist device was in place during the surgery; it was turned on at low flow and was left in place afterwards which helped to recover the left ventricle. The patient was then weaned from the device by turning it down and cardiac output was monitored. Next, the device was withdrawn and the patient survived and did well. Thus, this represents a different approach to handling a patient with cardiogenic shock. Unlike CPS, this approach does not require a membrane oxygenator because it uses the lungs; it takes the left atrial flow and allows the heart to rest so that it can recover some of its function when it is supported in this fashion.

James Zidar: That is a unique approach. Are you able to leave the assist device on for several days without incurring any red cell trauma? Is there much hemolysis taking place?

Howard Cohen: It’s an interesting point, Jim. I believe the device was in this patient for eight days. Initially, it was used as an implantable device in about 30 patients. It’s a good left ventricular assist device that doesn’t produce much in the way of hemolysis or red cell trauma. Also, as opposed to CPS, which you can only leave in for a few hours, this device can remain in place for several days with no apparent problem. Obviously, the longer the device is in place, the more likely infection will be, just as with the balloon pump, but it is a very powerful device. Unlike the balloon pump in patients with coronary disease, this device does allow for improved microvascular flow because the heart shrinks and the transmyocardial pressure gradient is significantly reduced.

Fayaz Shawl: As we discussed earlier, this would be a great device to use in patients who are in severe cardiogenic shock, are still “shocky” after revascularization, and have high LVDP.

James Zidar: Another problem we encounter involves intervening solely on the infarct-related vessel in “shocky” patients, as Jeff mentioned. We try to assess the condition of the patient’s ventricle—because patients like these often have mitral regurgitation. The question often boils down to: If these patients have multi-vessel disease, will the mitral regurgitation improve if you open up that vessel, or do these patients have at least moderate mitral regurgitation anyway? Thus, we are faced with left ventricular dysfunction, multi-vessel disease, and moderate mitral regurgitation for which the best course of treatment would be mitral valve repair and CABG. Our approach has typically been to treat the infarct-related artery—usually with a balloon pump—stabilize the patient over a period of 24–48 hours, perform a good echocardiogram at that point, and reassess mitral valve function. Does anyone here have a different treatment algorithm on how to handle mitral regurgitation in the setting of “shocky” patients?

Fayaz Shawl: In the mid-1980s we reported approximately ten cases which were published in the Journal of American College of Cardiology. These cases featured acute mitral regurgitation and acute infarction. It was interesting to note that there was no regurgitation on the echocardiogram. And in early intervention, the majority of patients had mitral regurgitation post-intervention. Thus, we open the vessel in the cath lab, then perform an echocardiogram. If the echo doesn’t reveal any regurgitation or frank rupture, a majority of the patients will show mitral regurgitation improvement.

Tom Linnemeier: Yes, that is a problem. The practitioners who are using t-PA or t-NK in the local emergency rooms are often not cardiologists; they are either E.R. physicians, family practice physicians or interns, and they are being sold lytics by local sales representatives. Although the lytic sales representatives are not telling these physicians that giving patients lytics will cure them, the immediate results greatly impress these practitioners who often see, after a lytic is given, that the patient’s terrible ST-segments are down to normal. So they think the patient is cured. But we all know what can happen: the patient returns to the emergency room and there are all these coagulation cascades which often make the procedure more difficult to perform. I really don’t know what the solution is—better education, perhaps. But I don’t think that the solution is a
second dose of a lytic agent. It is incumbent upon all of us in our respective communities to educate our local doctors about what they should do with these patients.

**Paul Overlie:** Jim, you asked if we had a strategy for dealing with mitral regurgitation patients who present with acute infarction. A strategy we strongly reinforce is when local physicians give these patients t-PA or t-NK, we have the patients sent to us so we can cath and treat them. That goes back to Bill O’Neill’s plea: Let us risk-stratify these patients and determine what their exact condition is so we can better guide our therapies.

**Luis de la Fuente:** Favaloro has operated on over 100 patients with acute myocardial infarction complicated by severe mitral regurgitation. He did come across a couple of patients in whom there was no rupture of the papillary muscle — they had significant acute mitral insufficiency from severe ischemia in the papillary muscle because the irritation of the papillary muscles is not identical in all the patients. Since then, when we see a patient with acute mitral insufficiency in acute infarction, and the artery is occluded — usually the circumflex — we try to open the artery. If the patient does not improve immediately we send him to surgery. The mortality rate with this approach is much lower.

**James Zidar:** In reference to what Kirk Garrett said about an area that needs further study, I’m not sure that randomized trials are good in cases of cardiogenic shock. However, a registry that studies a new mechanical device — perhaps the one Howard Cohen discussed — would be ideal for this situation. We need devices that are smaller and more user-friendly. That is one of the balloon pump’s advantages: you can use it in your everyday practice. CPS, on the other hand, is more invasive and uses bigger cannulas, which makes it difficult in patients with peripheral vascular disease. If the size of the cannulas is reduced and the device can be made more user-friendly — not that doing a transseptal would be an easy feat in shock cases — the technique would translate more easily into our everyday practices.

Is there anything different we can think of in the area of pharmacology for shock patients? I have been talking with Aventis about a sodium-potassium ion exchange and anti-inflammatory agent that the company is first testing in the controlled setting of bypass surgery. The agent aims to reduce inflammation, but you need the drug on board at the time of the injury, so their first foray into this has had the drug on board six hours before the patient is put on bypass. Perhaps acute myocardial infarction would also be a setting that could be studied. I don’t know much about this drug — it doesn’t have a name yet, just a series of numbers — but Aventis has shown some interesting animal work on this agent. Any other comments, Tom?

**Tom Linnemeier:** There are some companies involved in research that are toying with the idea of using stem cells at the time of acute myocardial infarction. They are working on the development of different types of delivery methods, whether it be an intra-myocardial delivery within the myocardium, a coronary sinus retroperfusion, or a direct intracoronary injection of the stem cells. I attended a thought leaders conference on the future of this technology. It seems like the biggest “bang for the buck” you get with stem cells is the more acute the injury, the more the cells want to go there. We also came to a solid consensus at this conference that the time of acute myocardial infarction is probably not ideal to deliver stem cells because of all the factors we’ve been discussing today — especially if it’s an intra-myocardial injection. The consensus among both the scientists and the clinicians was that two to four weeks post-myocardial infarction would be the appropriate time to deliver stem cells. Thus, in the area of biologics, stem cells represent another treatment modality that I think will be very significant in the coming years.

**James Zidar:** Doris Taylor, PhD, at Duke University, has been doing some myoblast work using an ameroid constrictor infarct in the LAD in pigs. At the time of the injury, a soleus muscle biopsy is taken, myoblasts are grown, and are then reinjected four to six weeks later. As we move from animal studies to humans — at least in the U.S. — it is a challenge to make it practical and not exorbitantly expensive to grow these myoblast cells in closed chambers under the rigors of good clinical practice guidelines, as is being done in the area of bone marrow transplantation. We have had meetings with our hematologists, oncologists, and our bone marrow group about how we could do this in a practical setting. I know they are starting to do this in Europe as well. Stem cells may be the treatment of choice in patients with large anterior myocardial infarctions. The patients would be given a soleus muscle biopsy at the time their LAD is reperfused, then return four to six weeks later to have myoblasts reinjected. Perhaps in a few years, this will be the standard of practice, who knows?
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