Metabolic interventions in acute myocardial infarction

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Chapter 1

General introduction and aims of the thesis

Diagnosis and treatment of ST segment elevation myocardial infarction

College of Cardiology (ACC)[5], and the American Heart Association (AHA)[5] requires a typical clinical syndrome plus a rise and fall in creatine kinase-MB (CK-MB) or tropinin.

Predictors of death in patients with myocardial ischemia and infarction

A number of prognostic models have been developed in populations of patients with ST segment elevation MI to determine the predictive value of several characteristics to predict outcome.[6-9] In the multinational, observational Global Registry of Acute Coronary Events (GRACE) the value of baseline clinical and demographic characteristics on hospital mortality was predicted in an unselected population of patients with acute coronary syndrome.[10] Killip class, age, blood pressure, cardiac arrest, positive enzymatic markers, serum creatinine level, ST segment deviation, and heart rate contained most of the prognostic information. Although acute coronary syndromes are usually categorized according to the presence or the absence of ST segment elevation at the time of presentation, this variable did not appear to be important for determining the risk of death after accounting for the presence of ST segment deviation. The risk of major cardiovascular complications and death is dependent on acute and pre-existing risk factors (table 1).

Table 1. High risk factors and markers of outcome

- Age
- Previous cardiovascular disease
- ST segment deviation
- Rhythm disturbances (bundle branch block, ventricular fibrillation, cardiac arrest)
- Signs of heart failure (Killip class ≥2)
- Glucose derangement (elevated glycosylated hemoglobin or diabetes mellitus)
- Renal dysfunction (raised serum creatinine, raised blood urea nitrogen, reduced creatinine clearance, micro-albuminuria)
- Elevated inflammatory markers (C reactive protein, interleukin-6)
- Extent of coronary artery disease on angiography (multi-vessel disease)
- Large enzymatic infarct size

General measures

The underlying principles of the treatment of ST segment elevation MI patients are to provide relief of ischemia and pain. In the presence of heart failure or shock, assisted

ventilation with positive end expiratory pressures may be required.[4;5] Reperfusion of critically ischemic myocardium is crucial in those with acute ST elevation or (new-onset) left-bundle branch block or posterior MI. Hemodynamic support may be necessary in patients with hypotension or cardiogenic shock, i.e., patients with Killip class 4 at admission. If so indicated, this supports intra-aortic balloon pumping to stabilize the patient for PCI. Specific measures may be required to control hypertension so as to reduce myocardial wall stress, and to treat acute heart failure.

Reperfusion therapy

Early and effective reperfusion therapy is the cornerstone of treatment for acute ST segment elevation MI. Restoration of antegrade flow in the occluded artery can be achieved by PCI and/or fibrinolytic therapy. To evaluate the coronary blood flow in patients with the Thrombolysis in Myocardial Infarction (TIMI) flow is determined. The restoration of TIMI grade 3 flow, i.e., optimal flow, is achieved in approximately 9 out of 10 patients treated with PCI as compared to 5-7 out of 10 patients treated with fibrinolytic therapy.[11] Early restoration of antegrade flow is related to diminished enzymatic infarct size, preserved left ventricular function, prevention of recurrent infarction, and short-term as well as long-term survival benefit.

Fibrinolytic therapy

The first two large-scale, placebo-controlled, randomized trials that compared fibrinolytic therapy with placebo demonstrated dramatic benefits for streptokinase. These two trials showed that streptokinase reduced 30-day mortality rates from 13% to 10.7% ($P<0.001$)[12] and 12% to 9.2% ($P<0.001$)[13]. These results also showed the synergistic benefits of antiplatelet agents and fibrinolytic therapy, since 30-day mortality was reduced to a greater extent by the combination of aspirin and streptokinase (13.2% versus 8.0%, $P<0.001$) than by aspirin alone (11.8% versus 9.4%, $P<0.001$).[12;13] Subsequent long-term data from both trials confirmed that the mortality benefit with streptokinase persisted for at least 10 years. Similar trials with other fibrinolytic agents have shown complementary findings, and a systematic overview of all trials randomizing more than 1000 patients to fibrinolytic therapy or placebo (total $N=58600$) reported a significant reduction in 30-day mortality with fibrinolytic therapy compared to placebo (11.5% versus 9.6%).[14] Prehospital administration of fibrinolytic therapy has been proposed as a means of further reducing time to reperfusion. Several studies have analyzed the potential advantages of prehospital fibrinolytics. A recent meta-analysis ($N=6434$) that combined data from six randomized trials showed a 17% reduction in mortality with prehospital fibrinolytics versus hospital-administered fibrinolytic therapy ($P=0.03$).[15] Fibrinolytic therapy is limited by various

safety and efficacy issues, such as contraindications and intracranial hemorrhage. However, until now the combination of glycoprotein IIb/IIIa receptor blockers or specific anti-thrombin (bivalirudin) and fibrinolytic therapy have not shown to improve survival, and may be associated with increased bleeding.

Primary percutaneous coronary intervention

Primary percutaneous coronary intervention (PCI) achieves reperfusion through mechanical recanalization of the infarct-related artery rather than through lysis of the coronary thrombus with fibrinolytic therapy. Dotter and Judkins were the first to propose the concept of reperfusion of the coronary artery by a catheter technique.[16] In 1977, Grüntzig performed the first percutaneous balloon angioplasty.[17] One year later, he and his colleagues reported that over a period of 18 months angioplasty had been used in 50 patients.[18] The technique was successful in 32 patients, reducing the stenosis from a mean of 84% to 34%. Percutaneous balloon angioplasty without the use of fibrinolytic therapy for acute MI was first described by Hartzler and colleagues in 1983.[19] The first stents were implanted in 1985.[20]

The number of trials comparing primary PCI with fibrinolytic therapy has been relatively small; however, these trials found an advantage for primary PCI. The first three randomized clinical trials comparing primary PCI with various fibrinolytic regimens were published in 1993. Zijlstra and colleagues found in 142 patients that compared to streptokinase primary PCI was associated with a lower incidence of the combined end-point of recurrent infarction or angina, death, stroke, reocclusion, and heart failure (19% versus 47% P=0.001).[21] Grines and colleagues found that primary PCI resulted in a lower rate of nonfatal reinfarction and death compared to tissue-type plasminogen activator (5.1% versus 12%, P=0.02) with a trend towards reduced overall mortality (2.6% versus 6.5%, P=0.06).[22] Gibbons and colleagues investigated in 108 patients the effect on myocardial salvage by technetium-99m-sestamibi and could not detect any improvement with primary PCI when compared to tissue-type plasminogen activator.[23] These pioneering trials were too small to determine the magnitude of the impact of mechanical reperfusion on mortality. Subsequently, Weaver and colleagues performed a meta-analysis incorporating data from the 10 available early trials that compared primary PCI with fibrinolytic therapy. Primary PCI was associated with a significantly lower rate of 30-day mortality (4.4% versus 6.5%, P=0.02), as well as with a significantly lower rate of the combined end-point of death or nonfatal reinfarction (7.2% versus 11.9%, P<0.001). Furthermore, Zijlstra and colleagues evaluated the 5-year results in patients randomly assigned to primary PCI versus streptokinase and showed a significant reduction in mortality in the primary PCI group (13.4% versus 23.9%, P=0.01).[24]

Current data are available from 23 published randomized controlled trials with 7739 patients.[25] Eight trials compared primary PCI to streptokinase (N=1837), and 15 primary PCI with fibrin-specific agents (N=5902). Of the 3867 patients randomly assigned to fibrinolytic therapy, most (76%, N=2939) received a fibrin-specific agent (tissue-type plasminogen activator). Stents were used in twelve and platelet glycoprotein IIb/IIIa receptor blockers in eight trials. The included trials differ in many respects, including patient sample size, type of fibrinolytic therapy, and whether the stents were used with or without platelet glycoprotein IIb/IIIa receptor blockers. Primary PCI was found to be more effective than fibrinolytic therapy in reducing short-term and long-term major adverse clinical events, including death. It was also associated with better clinical outcomes, regardless of the type of fibrinolytic agent used or whether the patient required emergent transfer to another hospital for primary PCI. Thus, primary PCI reduces mortality for patients with ST segment elevation MI even in high-risk patients. In the 'Should we emergenly revascularize Occluded Coronaries for cardiogenic shocK' (SHOCK) trial it was observed that at 1 year patients treated with PCI or coronary artery bypass grafting had a lower mortality than patients receiving fibrinolytic therapy (34% versus 47%, P=0.03). Postprocedural TIMI grade 3 flow rates in primary PCI trials have been as high as 73% to 97%, surpassing the 50% to 60% early TIMI grade 3 flow rates demonstrated with fibrinolytic therapy. Infarct-related artery reocclusion is also much less frequent after mechanical recanalization. Complications of PCI include the need for vascular repair and development of acute renal failure (approximately 3%).[26;27]

Additional treatment

To salvage viable myocardium by re-establishing coronary blood flow with the rapid use of reperfusion strategies is an essential first step. However, reperfusion of ischemic myocardium carries with it an inherent risk. Paradoxically, the process of reperfusion itself can result in myocyte death. This phenomenon is termed reperfusion injury. Mitochondria play a key role in determining cell fate during exposure to stress. Their role during ischemia/reperfusion is particularly critical due to the conditions that promote both apoptosis by the mitochondrial pathway and necrosis by irreversible damage to mitochondria in association with mitochondrial permeability transition. Mitochondrial permeability transition is caused by the opening of permeability transition pores in the inner mitochondrial membrane, leading to matrix swelling, outer membrane rupture, release of apoptotic signaling molecules such as cytochrome *c* from the intermembrane space, and irreversible injury to the mitochondria. During ischemia, factors such as intracellular calcium accumulation, fatty acid accumulation, and reactive oxygen species progressively increase mitochondrial susceptibility to mitochondrial permeability

transition, increasing the likelihood that mitochondrial permeability transition will occur on reperfusion. Since functional cardiac recovery ultimately depends on mitochondrial recovery, cardioprotection by ischemic and pharmacological preconditioning needs to involve the prevention of mitochondrial permeability transition. Experimental studies in animals suggest that it is possible to limit the amount of myocardial damage during ischemia and the early reperfusion periods. A variety of pharmacological approaches to prevention of injury (including vasodilators, adhesion molecule blockers, and receptor blockers of complement fractions) has been investigated. One of these potential additional treatments is metabolic intervention. Drugs such as ranolazine, trimetazidine, dichloroacetate, L-carnitine[28] and glucose-insulin-potassium (GIK) infusion and glucagon-like peptide[29] have mechanisms of action distinct from traditional anti-ischemic drugs.[30] These agents work by shifting myocardial energy metabolism away from free fatty acids (FFA) toward glucose as a source of fuel. Since these agents are well tolerated and do not affect heart rate or blood pressure, they conceivably could supplement traditional anti-ischemic drug therapy with little risk.

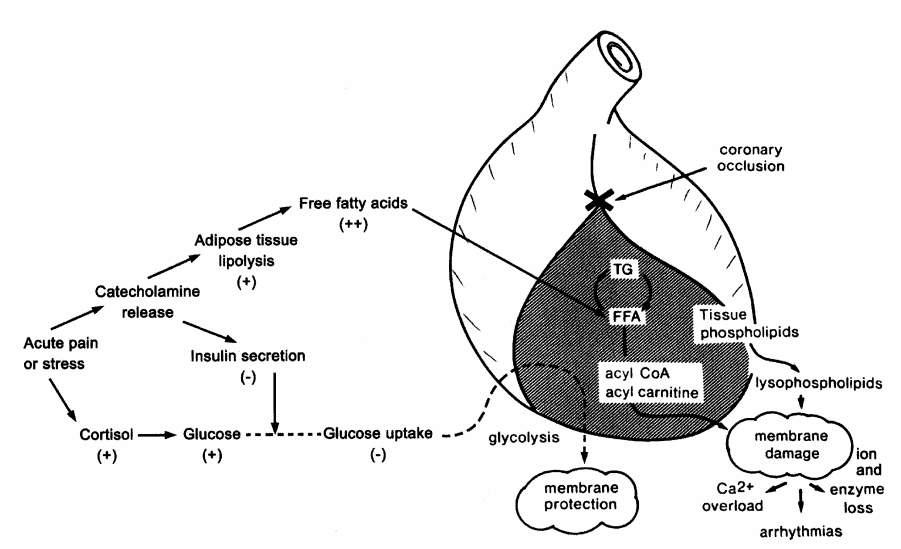
Glucose-insulin-potassium infusion in myocardial ischemia

In the timespan of almost a century, a large amount of experimental evidence has been accumulated that underlines the importance of glucose metabolism during ischemia/reperfusion of the heart. As early as 1912, Goulston suggested that treatment with glucose could be beneficial in several heart diseases.[31] The first experimental results on the mechanical effects of insulin and glucose in the isolated heart were made by Visscher and Muller in 1926.[32] In 1935, Evans and colleagues showed that in the ischemic myocardium the uptake of glucose is increased.[33] Almost 30 years later, Sodi-Pallares and colleagues suggested that metabolic interference during myocardial ischemia with GIK infusion decreased electrocardiographic signs of ischemia.[34] They also showed that GIK infusion resulted in a lower occurrence of arrhythmias.[34] They attributed this effect mainly to the influx of potassium in ischemic cardiomyocytes.[35] In order to further stimulate potassium transport into the cell, insulin was administered.[36] Consequently, the rise of intercellular calcium is curtailed by the influx of potassium and so the incidence of arrhythmias is reduced.[37-40] However, systemic infusion of insulin stimulates the uptake of glucose in many celltypes[41], which may result in hypoglycemic episodes.[42] Consequently, it is not possible to administer potassium and insulin in high concentrations without adding glucose. Interventions in the glucose metabolism in the clinical arena, whether or not used to correct acute hyperglycemia, encompass three potentially effective elements: glucose, insulin and potassium.

Basic mechanism of GIK protection

Ischemia induces many changes in the heart's metabolism, including shifts from aerobic fatty acid metabolism to anaerobic glycolysis, which provides energy for critical myocardial cellular function (figure 1).[43-45]

Figure 1. The main changes that occur in peripheral and myocardial metabolism during the development of acute myocardial ischemia. [adapted from Oliver MF. Am J Med 2002;112:305-311]



CoA = coenzyme A; FFA = free fatty acid; TG = triglyceride.

During most clinical ischemic syndromes, including acute MI, residual or collateral blood flow usually provides at least 10% of the normal level of perfusion to a significant portion of the ischemic myocardium. This small amount of perfusion provides such a level of oxygen delivery that oxidative ATP synthesis from both glucose and free fatty acids greatly exceeds ATP synthesis from anaerobic glycolysis.[46;47] Thus, a mixture of aerobic and anaerobic metabolism occurs. With progressively severe ischemia, anaerobic glycolysis becomes a progressively more important source of energy for a limited amount of ATP, which may or may not suffice to support the most essential cellular functions. Glycogen is rapidly mobilized during ischemia, and reduced glycogen concentrations impair force development, calcium release, and contractile function.[48] Key intermediates of the Krebs cycle are also depleted, which may impair energy transfer.[49]

The ischemia-mediated increase in glucose utilization is characterized by enhanced rates of exogenous glucose uptake in vivo, which requires greater rates of transport across the

plasma membrane.[50;51] Of the seven reported members of the facilitative glucose transporter family, GLUT-4 and GLUT-1 are the primary forms expressed in adult mammalian heart muscle.[52] During low-flow ischemia the expression of GLUT-4 is doubled.[53] Insulin increases the translocation of GLUT-4 via a pathway mediated by phosphatidylinositol 3-kinase (PI3-K). During ischemia and hypoxia GLUT-4 translocation is stimulated through a PI3-K-independent pathway. AMP-activated protein kinase plays a role in the translocation during ischemia.[54]

Table 2. Mechanisms of GIK infusion during myocardial ischemia[62-64]

- The yield of moles of ATP per mole of oxygen consumed is 11 percent higher for glucose than for FFA oxidation
- Anti FFA effects
    - Decrease of circulating FFA levels and myocardial FFA uptake
    - Increased esterification of intracellular FFA by increasing the supply of alpha-glycerophosphate
- Increased rate of ATP synthesis via anaerobic glycolysis with consequent beneficial effects
    - Increased concentrations of phosphocreatine and ATP
    - Blunting of an increase in inorganic phosphate and ADP concentrations
    - Increased free energy yield from ATP hydrolysis
- Increased myocardial glycogen
- Improved sodium and calcium homeostasis
- Increased tolerance to rises in intracellular calcium
- Replenishment of citric acid cycle intermediates by anaplerosis
- Increase of glucose and decrease of FFA oxidation during reperfusion
- Activation of cell survival signalling pathways such as Akt

Opie proposed the glucose hypothesis: the enhanced uptake and metabolism of glucose delays cellular damage.[55;56] Glucose utilization during ischemia prevents the breakdown of glycogen stores and leads to increased net intramyocardial glycogen synthesis, thereby limiting enzymatic infarct size and contracture.[47;57] Two studies showed that infusion of GIK in isolated hearts with regional ischemia resulted in decreased infarct size, increased high-energy phosphate levels, and improved ventricular function.[58;59] Acute MI patients treated with GIK also showed better stress tolerance and ischemic threshold improvement, analyzed with technetium-99m-tetrofosmin-gated SPECT.[60] The improved energetic profile results in improved systolic and diastolic function during ischemia and reperfusion, as well as coronary vasodilatation.[47] Also, glucose uptake has been shown to reduce hypoxia-induced apoptosis in cultured neonatal rat cardiac myocytes.[61] The

observed benefits of GIK infusion have been attributed to a number of mechanisms, which are summarized in table 2 and in part discussed.

Glucose

The potential positive effects of glucose are based on the fact that glucose is a source of energy for cells.[65] The uptake of glucose into the cell is influenced by insulin, although there is also an insulin-independent transport of glucose.[66] It has been observed that AMP-activated protein kinase is responsible for activation of glucose uptake and glycolysis during low-flow ischemia.[67] During MI, low-flow perfusion of the ischemic area is often present, making the administration glucose useful.[48] In an experimental study it was observed that a high glucose concentration stimulated translocation of GLUT-4.[68] It was already know that the combination of glucose and insulin is more effective than either one alone in stimulating glycolysis under ischemic conditions.[47]

Administering glucose can prevent insulin-induced hypoglycemia. When the hypoglycemic episodes persist or when they are severe (<2.7 mmol/L), convulsions, brain damage and even brain death may occur.[69] Hypoglycemia is also related to myocardial ischemia.[70] It has been shown that the prevention of hypoglycemia can prevent an increase in enzymatic infarct size.[71] When hypoglycemia occurs, the contraregulating hormones are activated and result in an increased release of glucose.[72] Increased glucose release requires, in particular, an increase in glucagon and adrenaline. During MI the levels of glucagon, adrenaline and aldosteron among others are already elevated.

Insulin

The potential positive effects of insulin during stress situations are multifarious.[73;74] First, insulin is involved in the uptake of glucose in tissues, including the myocardium, mainly through GLUT-4 and partly through GLUT-1.[75] However, the exact amount of uptake during ischemia is disputable.[76] Besides the stimulation of glucose uptake and the stimulation of glycogen synthesis, insulin is also involved in gene transcription, expression of various metabolic enzymes, the activation of various pathways with mitogenic activity, and even fatty acid uptake. The insulin receptor substrate 1 has an important role in realizing this pleiotrope.[77] Both insulin-like growth factor (IGF) 1 and insulin inhibit postischemic apoptosis, energetic failure and damage to cardiac tissue, in vitro and in animals, possibly through reduced oxidative stress.[78;79] Insulin increases the bio-availability of IGF1 and suppresses hepatic synthesis of IGF1-binding protein, which binds and limits free-circulating IGF1.[80;81]

Insulin stimulates protein synthesis in skeletal muscles and inhibits intracellular protein breakdown in cardiac tissue.[82-84] The preservation of myocardial cells by inhibiting apoptosis and reduced destruction of proteins could be the reason that contractibility is

preserved.[85] An additional factor is that insulin potentiates ischemic preconditioning; however, this has not been proven irrefutably in clinical trials.[86;87]

Insulin has an anti-inflammatory effect that is caused by a reduction in oxidative stress.[88] First, insulin reduces the pro-inflammatory effects of hyperglycemia. Insulin suppresses the production of tumor necrosis factor α in macrophages, leucocytes and endothelium.[89] Furthermore, insulin blocks the upregulation of the endothelial cell adhesion molecule induced by hyperglycemia.[90;91] Also, insulin inhibits macrophage-inhibitory factor, and potentiates endothelial nitric oxide synthase and endothelin release.[92] In a clinical study it appeared that the oxidative stress that occurs in myocardial ischemia and during reperfusion by primary PCI could not be suppressed by insulin.[93]

Insulin is shown to influence the adhesion of leucocytes and blood platelets during an acute MI.[94] A study with 48 patients with type 2 diabetes mellitus showed that intensive treatment with insulin during an acute ischemic event (i.e., acute MI or unstable angina pectoris) improves the fibrinolytic profile.[95] The administration of insulin with the aid of an algorithm led to lower mean blood-glucose values (6.9 mmol/L versus 11.4 mmol/L) and to lower concentrations of tissue plasminogen activator, plasminogen activator inhibitor-1 and fibrinogen.

Insulin has vasodilating capacities in blood vessels of muscle tissue.[96;97] Vasodilatation during myocardial ischemia has been observed both in patients with and without diabetes mellitus.[97-99] This is advantageous, since it opens up the blood vessels in the myocardium, enabling more glucose to reach the cells and preventing the accumulation of metabolites that are toxic and cause mitochondrial damage and alterations in membrane ion channels.[98;100] Vasodilatation occurs, among others, by stimulating the production of nitric oxide in the endothelium and by antagonizing endothelin, a potent vasoconstrictor.[101;102] Even a small increase in myocardial blood flow can significantly reduce myocardial ischemia.[103]

Conversely, administering insulin can potentially lead to an adverse reaction.[104] It might lead to enhanced polarisability of the cell membrane, stimulation of the sympathetic nervous system, and inhibition of the parasympathic nervous system. In contrast to the above-mentioned results, it was also found that insulin induced oxidative stress.[105] The effect of insulin on nuclear factor-κB (NF-κB) remains unclear.[88;106] In an experimental setting insulin in high amounts has inhibitory effects on intermediates involved in the activation by platelet-derived growth factor.[107]

Potassium

It appears that hypokaliemia during stress situations is disadvantageous.[108;109] Hypokaliemia frequently occurs in trauma patients and has been associated with a worse score on the Glasgow Coma Score (GCS).[110] Moreover, hypokaliemia has been associated

with muscle necrosis and paralysis. In patients with myocardial ischemia, hypokaliemia increases the risk of ventricular arrhythmias and acute cardiac arrest.[111] Restoring the potassium concentration in the cell and in serum may be accompanied by a decrease in the incidence and severity of arrhythmias.[112] However, when the effect of GIK infusion on QT-time was analyzed, no effect was found.[113] Consequently, administration of potassium in stress situations is mandatory to patients who present with hypokaliemia as well as to patients treated with insulin in order to prevent hypokaliemia. Moreover, hypokaliemia appears to suppress the secretion of insulin, and in this way stimulates a (continued) state of hyperglycemia.[114]

This thesis

This thesis is a new branch on the large tree of studies on optimal therapeutic strategy for and understanding of ST segment elevation MI. In 1989, the Zwolle Myocardial Infarction Study Group performed its first study of comparing PCI with streptokinase. Thereafter studies on the effect of primary PCI, stenting, intra-aortic balloon counterpulsation, prehospital treatment with heparin and glycoprotein IIb/IIIa receptor blockers have been reported. Over the last years more research has been done to investigate the causative mechanisms behind favorable and unfavorable outcome after treatment with primary PCI. Currently, special emphasis is given to the effect of glucose derangements and patients with diabetes mellitus. The concept to add a metabolic intervention to the treatment strategy of primary PCI was formulated in 1997.

The purpose of this thesis is to investigate the effect of metabolic interventions and disturbances on the clinical outcome and myocardial function in ST segment elevation MI patients. Therefore, we have investigated whether GIK infusion in adjunction to primary PCI reduces 30-day (Chapter 2.1) and 3-year mortality (Chapter 2.6) in ST segment elevation MI patients. We also investigated the effects of GIK infusion on myocardial infarct size (Chapter 2.2), left ventricular function (Chapters 2.2 and 2.3) and ST segment elevation resolution (Chapter 2.4). Furthermore, we investigated the metabolic derangements induced by GIK infusion, and the impact of metabolic derangements on clinical outcome (Chapter 2.5). With the results of the GIPS we performed a new analysis on all available results of GIK infusion on 30-day mortality (Chapter 3).
In the second part of this thesis we report our studies on the relation between hyperglycemia and outcome. Based on a large body of evidence it is known that hyperglycemia at admission is related to mortality. We were able to analyze the effect of admission hyperglycemia on myocardial function (Chapter 4.1). The predictive value of

admission glucose is not strong and we hypothesized that persistent hyperglycemia in both critically ill patients admitted to a Coronary Care Unit (Chapter 5.1) and an Intensive Care Unit (Chapter 5.2 and 5.3) could be a better determinant for unfavorable outcome. Based on the results found in the above-mentioned studies, we wrote the protocol of the GIPS-2 a multi-center trial on the effect of GIK infusion in ST segment elevation MI patients without signs of heart-failure and eligible for reperfusion therapy (Chapter 6). Finally, this thesis purposes to give future directions for the implementation of metabolic interventions in critically ill patients (Chapter 7).

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Introduction

Treatment strategies for acute ST segment elevation myocardial infarction (MI) have evolved over the last 25 years. In the 1950s and 1960s, it was debated whether coronary thrombosis was the cause or the consequence of ST segment elevation MI. In the 1960s and 1970s, treatment of ST segment elevation MI patients consisted of bed rest for up to a month. Mortality was reduced with the emergence of Coronary Care Units and treatment of the arrhythmias. Landmark studies by DeWood in the early 1980s showed that occlusion of the coronary artery was the critical event leading to ST segment elevation MI.[1] Reperfusion therapy became the cornerstone of acute treatment for ST segment elevation MI. Preferentially, acute coronary reperfusion is nowadays accomplished (1) mechanically by primary percutaneous coronary intervention (PCI), previously called primary transluminal coronary angioplasty (PTCA) with or without stenting or (2) pharmacologically with intravenous fibrinolytic therapy. Recent evidence suggests that apart from improved PCI techniques, adjunctive use of platelet glycoprotein IIb/IIIa receptor blockers and metabolic interventions, such as glucose-insulin-potassium (GIK) infusion may enhance procedural success and improve clinical outcome. Together these developments have stimulated renewed efforts to determine the optimal therapeutic strategy for patients with ST segment elevation MI.

Pathophysiology

The first papers on the clinical diagnosis of MI date from the early 20th century. Obrastzow and Stracheschenko in 1910 and Herrick in 1912 described the features of a sudden obstruction of a coronary artery.[2;3]

Myocardial infarction is the consequence of disruption, fissuring or hemorrhage of a vulnerable coronary artery plaque, complicated by various degrees of intraluminal thrombosis, embolization, and subtotal or total obstruction to perfusion. The residual antegrade or collateral flow, and the volume and location of affected myocardium determine the characteristics of the clinical presentation. Patients with complete occlusion may manifest ST segment elevation MI, if the lesion occludes an artery supplying a substantial volume of the myocardium. A similar occlusion in the presence of extensive collaterals may present as MI without ST segment elevation. ST segment elevation MI is diagnosed by the presence of a clinical syndrome of new-onset ischemia with either rest pain or a crescendo pattern of ischemic pain on minimal exertion, and elevated enzymatic markers together with electrocardiographic evidence of acute ischemic injury. The predictive accuracy of ST segment elevation for a final diagnosis of MI is very high. The definition of MI proposed by the European Society of Cardiology (ESC)[4], the American

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