Primary reperfusion in acute right ventricular infarction: An observational study

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Abstract

AIM: To investigate the impact of primary reperfusion therapy (RT) on early and late mortality in acute right ventricular infarction (RVI).

METHODS: RVI patients (n = 679) were prospectively classified as without right ventricular failure (RVF) (class A, n = 425, 64%), with RVF (class B, n = 158, 24%) or with cardiogenic shock (CS) (class C, n = 96, 12%). Of the 679 patients, 148 (21.7%) were considered to be eligible for thrombolytic therapy (TT) and 351 (51.6%) for primary percutaneous coronary intervention (PPCI). TIMI 3-flow by TT was achieved for A, B and C RVI class in 65%, 64% and 0%, respectively and with PPCI in 93%, 91% and 87%, respectively.

RESULTS: For class A without RT, the mortality rate was 7.9%, with TT was reduced to 4.4% (P < 0.01) and with PPCI to 3.2% (P < 0.01). Considering TT vs PPCI, PPCI was superior (P < 0.05). For class B without RT the mortality was 27%, decreased to 13% with TT (P < 0.01) and to 8.3% with PPCI (P < 0.01). In a TT and PPCI comparison, PPCI was superior (P < 0.01). For class C without RT the in-hospital mortality was 80%, with TT was 100% and with PPCI, the rate decreased to 44% (P < 0.01). At 8 years, the mortality rate without RT for class A was 32%, for class B was 48% and for class C was 85%. When PPCI was successful, the long-term mortality was lower than previously reported for the 3 RVI classes (A: 21%, B: 38%, C: 70%; P < 0.001).

CONCLUSION: PPCI is superior to TT and reduces short/long-term mortality for all RVI categories. RVI CS patients should be encouraged to undergo PPCI at a specialized center.

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Key words: Right ventricular infarction; Reperfusion therapy; Ventricular failure; Cardiogenic shock; Morbidity; Mortality

Core tip: It is, up to our knowledge the largest series of
acutely right ventricular infarction (RVI) patients where all the clinical RVI spectrum is considered. RVI is analyzed in relation to primary reperfusion procedures, over a study period with a more widespread use of primary percutaneous coronary intervention (PPCI) together with the advent of stents and antiplatelet agents to provide a better insight into reperfusion trends and results in acute RVI. According to our findings, in all RVI hemodynamic scenario PPCI is superior to thrombolytic therapy (TT) and reduces short and long-term mortality for all 3 RVI categories. Patients in cardiogenic shock should be encouraged to undergo PPCI rather than TT at a specialized center.

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INTRODUCTION

Right ventricular infarction (RVI) is relatively common in patients with acute inferior-posterior left ventricular myocardial infarction (IPLVMI). RVI can depress right ventricular (RV) function, resulting in right ventricular failure (RVF) or cardiogenic shock (CS). There are scarce and somewhat conflicting clinical data concerning the effects of interventions designed to achieve reperfusion of the RV myocardium in acute ischemia. Several investigators have suggested that RV function improves only after successful thrombolytic therapy (TT), whereas others have reported recovery in the absence of early or even any reperfusion of the right coronary artery (RCA). In a study involving limited number of patients, rapid hemodynamic improvement and excellent clinical outcomes have been reported after successful primary percutaneous coronary intervention (PCI) of the RCA and its major RV branches. At the most extreme end of the hemodynamic spectrum for RVI, when CS is analyzed in relation to reperfusion, the results can be disappointing, partly due to the time frame of the study (1993-1998), or the results can be better than the outcomes in patients with left ventricular (LV) pump failure in a study from 1984 to 2004. The present study aimed (1) to evaluate the trends and impact of TT and PPCI over time and on early and late mortality in RVI patients with or without RVF; and (2) with CS over a study period with a more widespread use of PPCI together with the advent of stents and potent antiplatelet agents to provide a better insight into reperfusion results in acute RVI.

MATERIALS AND METHODS

Ethics

This work has been carried out in accordance with the Declaration of Helsinki (2000) of the World Medical Association. The protocol was approved by the ethics committee of the institution. All patients provided informed written consent.

Patients

We prospectively screened 2679 consecutive patients admitted with a first acute (defined as the time from symptom onset to admission of ≤ 48 h) IPLVMI (defined as chest pain with > 1 mm in leads II, III and aVF) from January 1996 to March 2009, and identified 679 (25.3%) patients with infarction extending to the walls of the right ventricle (84% were studied in the last 10 years). Isolated acute RVI, history of valve heart disease, and previous heart or renal failure were exclusion criteria for this study.

The diagnostic criteria for IPLVMI with extension to the walls of the right ventricle, RVF and CS have been published previously. Briefly, in addition to standard electrocardiographic (EKG) leads, a right-sided precordial EKG (leads V7-V9) was recorded in all patients immediately after admission. An ST-segment elevation in lead V9 or V10 of greater than 0.1 mV was used to diagnose RVI. The diagnosis of RVI was also based on clinical features that have been described and have been associated with this variety of infarction, and on echocardiographic findings. The diagnosis of RVF was based on clinical features, including persistent systemic hypotension [systemic systolic pressure (SSP) ≤ 100 mmHg], right-sided S1 and S4 without features of shock, echocardiographic evidence of ischemic RVF (RV wall motion abnormalities (WMA) associated with gross RV dilatation), findings that suggest globally depressed RV function and invasive hemodynamic monitoring. In this study, patients were considered to have shock when two of the following criteria were satisfied: SSP persistently ≤ 90 mmHg or vasopressors required to maintain SSP > 90 mmHg; very low CO [cardiac index (CI) < 2.1 L/min/m²]; evidence of end-organ hypoperfusion. We did not include in this category patients with hypotension related to hypovolemia, transient hypotension due to vasodilatation and bradycardia associated with spontaneous reperfusion (Bezold-Jarisch reflex), or hypotension due to atioventricular block (AVB), cardiac arrhythmias or mechanical complications (ventricular septal or myocardial wall rupture or cardiac tamponade) at admission.

We risk-stratified RVI patients into 3 subsets based on clinical features, echocardiographic findings upon admission and hemodynamic findings as follows: class A (without RVF), comprised of patients without evidence of systemic hypotension (SSP ≥ 100 mmHg) or RVF (by clinical features, echocardiographic and/or hemodynamic findings); class B (with RVF), those with persistent systemic hypotension (SSP < 100 mmHg) or RVF, but without other clinical features of shock; class C, those with...
patients with inferior-posterior left ventricular myocardial infarction (IPLVMI) (n = 2679), with right ventricular infarction (RVI): 679 (25.3%). We risk-stratified RVI patients into 3 subsets: class A (without RVF), class B (with RVF) and class C (with cardiogenic shock). WI: Without intervention; TT: Thrombolytic therapy; PCI: Primary coronary intervention; RVF: Right ventricular failure.

**Evaluation of atrial and ventricular function**

Echocardiograms were analyzed according to previous methods[4]. LV systolic dysfunction was defined as an ejection fraction below 50%. The RV was divided into eight segments; of these segments 3 corresponded to the basal segments, 3 to the middle segments of the anterior, lateral and inferior walls (IW), and 2 to the apical anterior and inferior segments. The wall movement index (WMI) of both ventricles was obtained by assigning a value to the movement of each wall segment and dividing the sum by the number of segments corresponding to the ventricle in question. A score of 0 was classified to normal movement, 1 as = hypokinesis (diminished thickening), 2 as = akinesis (absence of thickening) and 3 as = dyskinesis (paradoxical systolic movement). The overall score for RV and LV wall motion (LVWM) was calculated as the average score for the segments, and the ratio of the diastolic diameters of the two ventricles diastolic ratio of the two ventricles (RVD/LVD) was also calculated. The echocardiographic evidence of ischemic RV was based on a combination of the following features: right ventricular wall motion abnormalities (RVWMA) and RV dilatation with/without tricuspid regurgitation (TR). Right atrial (RA) ischemia was defined according to the following criteria: akinesis of the RA free wall (FW) despite left atrial contraction, thrombosis at the site of akinesis, presence of spontaneous contrast in the RA, and inversion of the interatrial septal convexity[10].

**Evaluation of coronary anatomy and perfusion**

The location of the culprit lesion was assessed using Bowers criteria[3]. The initial and post-reperfusion flow grades in the coronary artery and in the RV branches were scored from 0 to 3 [thrombolysis in myocardial infarction (TIMI) flow classification]. Successful reperfusion was defined as < 50% residual stenosis and restoration of TIMI grade 3 in the main RCA and its major RV branches (> 1 mm). Coronary collateral blood flow was evaluated according to Rentrop et al[10]. Multivessel disease was defined as a lesion >= 50% in >= 2 major coronary arteries. We analyzed all of the patients who had a coronary angiogram at admission and a second angiogram after reperfusion. For those who received TT, the second coronary angiogram was performed 90-180 min after the thrombolytic infusion. Information on the coronary arteries was evaluated independent of and blinded to the other study data.

**Treatment protocol**

Patients were treated with unfractionated heparin (bolus: 60 IU/kg, maximum 5000 IU; 10 IU/kg per hour, maximum 1000/h) and aspirin (300 mg) in the emergency room and transferred to the coronary care unit or to the catheterization laboratory to undergo coronary angiography, based on the individual’s. Patients who were eligible for reperfusion were consecutively assigned to TT or PPCI. TT was administered intravenously to all of the eligible RVI patients. The inclusion criteria for classes A and B were defined before admission as follows: symptoms of ST elevation myocardial infarction (STEMI) lasting less than 12 h or > 12 h in patients with ongoing ischemia, age <= 75 years and absence of other accepted contraindications. TT was performed with either streptokinase (32%) or recombinant tissue plasminogen activator (68%), preceded by heparin. Post-TT consisted of an intravenous heparin dose that was adjusted to maintain TPTa between 60-75 s for 72 h and aspirin. For PPCI, the same inclusion criteria for STEMI symptoms and duration and age were applied; stents were deployed according to standard techniques followed by standard anti-platelet therapy. Stents and glycoprotein IIb/IIIa platelet inhibitors became a standard therapy in eligible patients in 1995 and 1996, respectively. Clopidogrel was used in stented patients with a loading dose of 300 mg or 600 mg later, a daily dose of 75 mg for > 6 mo in patients treated with bare metal stents and for 6 to 12 mo in patients treated with drug-eluting stents. RVI patients in shock were considered to be candidates for PPCI if age
sent for reperfusion were compared to those who were not referred for reperfusion; and (4) within each class, TT to PPCI was compared.

The continuous data are expressed as the mean ± SD unless otherwise specified. A Student’s t-test, 1-way-ANOVA (Bonferroni’s-test for multiple comparisons), \( \chi^2 \), or Fisher exact test was used as appropriate.

Univariate analysis based on the logistic regression model was used to examine the relationship between the selected demographic, medical history, clinical examination, and hemodynamic data to determine the likelihood of overall mortality. After the univariate analysis, any variable that had a univariate test value of \( P < 0.25 \) was considered to be a candidate for the multivariate analyses. The results are expressed as odds ratios and 95%CI. The Kaplan-Meier method was used to estimate the overall survival distribution (log-rank test). The analyses were performed using the STATA-9 software.

RESULTS

Clinical data
From all of the RVI patients, echocardiography, invasive hemodynamic evaluation and coronary angiograms were performed in 94.5%, 89% and 73%, respectively. The diagnosis of RVI was made by EKG, echocardiographic, hemodynamic or coronary angiographic criteria in 100% and by 3 criteria (echocardiographic, hemodynamic and angiographic) in 85% of the patients. The RVI subgroups had no differences in their baseline clinical characteristics (Table 1).

Echocardiography
At baseline, there was evidence of IPLVMI dysfunction in all of the RVI patients (WMI 1.8 ± 0.4). The echocardiographic data at baseline by clinical class was documented as follows. In all of the classes A patients without RV-dilatation, WMA were only found in the IW (LV + RV) = 84% and the FW = 16%. In class B and C patients with RV-dilatation, WMA was not only confined to the IW, TR, and abnormal ventricular septal movement were observed in 78% and 70%, respectively, with abnormal RA wall movement in 18% and 25%, respectively. Abnormal values for the right ventricular motion index were found in all of the patients, with a significant increase in the WMA score classes between A, B and C classes (> 48 h after the onset of myocardial infarction). Patients underwent PPCI or coronary artery bypass graft surgery (CABGS) only if ischemia recurred despite medical therapy during hospitalization or occurred during a pre-discharge stress test.

Morbidity and mortality analysis
The following adverse cardiac events were recorded: hypotension (> 1 h), hypotension necessitating volume infusion (200-400 mL/h), pharmacological hemodynamic support (inotropic agents/vasopressors), or intra-aortic balloon pump (IABP); high grade AVB (> 1 h, need for a transient pacemaker); ventricular arrhythmias requiring treatment; recurrent ischemia (defined as recurrent chest pain with or without new EKG changes or recurrent myonecrosis as indicated by serum biomarkers [increase in creatine kinase level and MB fraction higher than the nadir]; death. Urgent target vessel revascularization was defined as the need to repeat PPCI or urgent CABGS for recurrent ischemia or hemodynamic compromise during the hospital stay.

The primary end point was in-hospital cardiac death at 30 d. Follow-up information after hospital discharge was obtained from the hospital records database, which is updated at each patient visit and upon patient death.

Statistical analysis
We analyzed: (1) the clinical, echocardiographic, angiographic and hemodynamic characteristics of our patients at baseline separately for those in classes A, B, and C; (2) among the 3 RVI classes; (3) within each class, all patients sent for reperfusion were compared to those who were < 75 years and shock developed within ≤ 48 h of the STEMI.

Conservative therapy for A and B class was provided to patients who delayed seeking medical attention, for class C > 75 years of age or those who developed shock > 48 h after the onset of myocardial infarction. Patients underwent PPCI or coronary artery bypass graft surgery (CABGS) only if ischemia recurred despite medical therapy during hospitalization or occurred during a pre-discharge stress test.

Table 1 Clinical characteristics of the 679 patients separated according to right ventricular infarction class

| Variables          | Class A          | Class B          | Class C          |
|--------------------|------------------|------------------|------------------|
| n                  | n = 425 (64%)    | n = 158 (24%)    | n = 96 (12%)     |
| Age (yr)           | 59.7 ± 9.4       | 61 ± 10          | 62.4 ± 8.4       |
| Age 64-74 yr       | 41.9%            | 38.7%            | 37.5%            |
| Men                | 82%              | 81%              | 83%              |
| Pre-IA             | 38%              | 40%              | 41%              |
| Peak CK IU/L       | 1854             | 1994             | 2109             |
| median (25%-75% percentiles) | (1654-2490) | (1214-2634) | (1532-2812) |
| Peak MB fraction IU/L | 188             | 201              | 192              |
| median (25%-75% percentiles) | (111-350) | (126-312) | (104-333) |
| Diabetes           | 26.9%            | 27.8%            | 30.6%            |
| Hypertension       | 40.7%            | 44.3%            | 44.4%            |
| Hypercholesterolemia | 23%            | 19%              | 21%              |
| Smoking            | 58%              | 60%              | 55%              |
| BMI (kg/m²)        | 28.2 ± 4.4       | 26.7 ± 5.2       | 27.2 ± 3.9       |

No statistically significant differences between right ventricular infarction classes were found. Pre-IA: Infarction angina; CK: Creatine kinase; BMI: Body mass index; MB: Myocardial B.
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Table 2 Echocardiographic data at baseline according to right ventricular infarction class

| Variable                          | Class A          | Class B          | Class C          | Total          |
|-----------------------------------|------------------|------------------|------------------|----------------|
|                                  | (n = 396)        | (n = 152)        | (n = 94)         | (n = 642)      |
| RV-dilatation                     | 0%               | 100%             | 100%             | 100%           |
| VVMA                              | 100%             | 100%             | 100%             | 100%           |
| WMA only for IW                   | 84%              | 0%               | 0%               | 51.7%          |
| WMA for IW + OW                   | 16%              | 100%             | 100%             | 48%            |
| TR                                | 17%              | 100%             | 100%             | 48%            |
| AVSM                              | 25%              | 78%              | 70%              | 43.9%          |
| RVMI                              | 1.9% ± 0.3%      | 2.5% ± 0.2%      | 3.4% ± 0.5%      | 2.4% ± 4%      |
| RVD/LVD > 1                       | 0%               | 25%              | 18%              |                |
| RVD/LVD = 1                       | 0%               | 65%              | 18%              |                |
| ARAWM                             | 0%               | 18%              | 25%              | 8%             |
| RA-DPS (%)                        | 0 (0)            | 19 (70)          | 10 (43)          | 29 (58)        |
| LVEF ≤ 0.5                        | 11%              | 22%              | 34%              | 16%            |

Echocardiographic data at baseline according to right ventricular infarction class (n = 642/679, 94.5%); transthoracic (TT): 375 (58%), transesophageal (TE): 267 (42%). \( p < 0.000 \) vs classes A; \( p < 0.01 \) vs classes B. RV: Right ventricle; VVMA: Ventricular wall motion abnormalities; IW: Inferior wall for LV + RV; OW: Other walls; TR: Tricuspid regurgitation; AVSM: Abnormal ventricular septal motion; RVMI: Right ventricular motion index (mean ± SD); RVD/LVD: Diastolic ratio of the two ventricles; ARAWM: Abnormal right atrial wall movements; RA-DPS: Right atrium dobutamine positive stress; LVEF: Left ventricular ejection fraction.

Table 3 Hemodynamic data at baseline according to the right ventricular infarction class

| Variable                          | Class A          | Class B          | Class C          | Total          |
|-----------------------------------|------------------|------------------|------------------|----------------|
|                                  | (n = 350)        | (n = 158)        | (n = 96)         |                |
| mRAP (mmHg)                       | 4.6 ± 2.1        | 12.9 ± 3.6       | 21.4 ± 5.1\(^*\) |
| REVDP (mmHg)                      | 3.4 ± 1.7        | 11.2 ± 4\(^*\)   | 16 ± 5.4\(^*\)  |
| sPAP (mmHg)                       | 16.2 ± 4.4       | 16.4 ± 3.9       | 36.8 ± 9.3\(^*\) |
| dPAP (mmHg)                       | 9.7 ± 3.7        | 13.4 ± 2.2       | 22.2 ± 3.9\(^*\) |
| mPWP (mmHg)                       | 8.6 ± 3.1        | 12.1 ± 1.8       | 19.9 ± 6.2\(^*\) |
| CI (L/min/m²)                     | 3.4 ± 0.71       | 2.4 ± 0.21\(^*\) | 1.67 ± 0.5\(^*\) |
| mSAP (mmHg)                       | 108.8 ± 7        | 78.7 ± 12\(^*\)  | 62.7 ± 9.5\(^*\) |
| RAP/PWP ≥ 0.8                     | 2%               | 96%              | 92%              |

Hemodynamic data at baseline according to the right ventricular infarction class (n = 604/89%, \( p < 0.000 \) vs classes A; \( p < 0.01 \) vs classes B. m: Mean; s: Systolic; d: Diastolic; RAP: Right atrial pressure; REVDP: Right ventricular end diastolic pressure; PAP: Pulmonary artery pressure; PWP: Pulmonary wedge pressure; CI: Cardiac index; SAP: Systemic arterial pressure.

Angiography

The RCA was the infarct-related artery in 95% of the RVI patients. There was severe compromise of RV perfusion, as indicated by the TIMI grade flow (0.7 ± 1).

The culprit RCA lesion was most commonly found proximal in class B and C patient and had a mid location in class A patients. The 3 RVI subgroups had no differences in prevalence of 1 and 2 vessels disease (YD), but 3-VD was more frequently observed in classes B and C.

Reperfusion

Of the 679 RVI patients, 148 (21.7%) were eligible for TT and 351 (51.6%) for PPCI. TIMI 3-flow by TT was achieved for 65%, 64%, and 0% for RVI classes A, B, and C. TIMI 3-flow was achieved with PPCI in 93%, 91%, and 87%, respectively. The mean residual coronary artery lesion at 90-180 min for the group RVI patients treated with TT or PPCI was 68% ± 10% and 10% ± 8%, respectively (\( P < 0.000 \)).
Table 5  Procedural variables and results of primary reperfusion at entry according to right ventricular infarction class (n = 679)

| Variable | Class A (n = 425) | Class B (n = 158) | Class C (n = 96) | Total |
|----------|------------------|------------------|------------------|-------|
| Symptoms to admission time (min-max) h | 4.6 (2-23) | 5.5 (3.4-19) | 27 (19-48)† | 27 (19-48)† |
| Medical treatment | 111 (26) | 44 (27) | 25 (26) | 180 (26.5) |
| TT | 109 (25) | 30 (19)‡ | 9 (9) | 148 (21.7) |
| Primary PCI | 205 (48) | 84 (53) | 62 (64) | 351 (51.6) |
| Stent use | 182 (88) | 80 (95) | 62 (100) | 324 (92) |
| PCI/BA/GI use | 40% | 47% | 52% | 54% |
| Inotropes/vasopressors | 0% | 100%† | 100% | 100%† |
| Temporary pacemaker | 1.20% | 10.7%‡ | 29%§ | 14%‡ |
| IABP support | 0 | 0 | 73.9% | 73.9% |
| MVA | 0 | 0 | 100%§ | 100%§ |
| Median time from MI to reperfusion treatment (min-max) h | 1.9 (1.3-4) | 2.1 (1.4-3.8) | 14 (8-22)§ | 14 (8-22)§ |
| Door-to-needle time (min) | 42 ± 18 | 48 ± 16 | - | - |
| Door-to-balloon time (min) | 93 ± 24 | 89 ± 37 | 198 ± 102‡ | 198 ± 102‡ |
| TIMI 3 flow after PCI | 93% | 91% | 87% | 90% |
| TIMI 3 flow after TT | 65% | 64% | 0% | 0% |
| RCA-Extensive clot burden | 17% | 22% | 75% | 75% |
| At 24-48 h reversal of RVWMA with SR | 84% | 78% | 69% | 69% |

†P < 0.01 vs classes A; ‡P < 0.01 vs classes B. TT: Transthoracic; PCI: Primary coronary intervention; IABP: Intra-aortic balloon pump; MVA: Mechanical ventilatory assistance; RCA: Right coronary artery; SR: Success reperfusion; RVWMA: Right ventricular wall motion abnormalities; GI: Glucoprotein inhibitors; MI: Myocardial infarction; TIMI: Thrombolysis in myocardial infarction.

Table 6  Hospital outcomes based on reperfusion for each RVI class (n %)

| Variable | Class A (n = 111) | Class B (n = 205) | Class C (n = 84) | Total (n = 158) |
|----------|------------------|------------------|------------------|----------------|
| AVB+ | 16 (14) | 7 (6)§ | 11 (5) | 34 (21) |
| SVT/PAT+ | 18 (16) | 6 (5)§ | 9 (4) | 33 (8) |
| AF/PAT | 4 (3) | 5 (2.7) | 0 (0) | 7 (1.6) |
| R-MI+ | 6 (5) | 8 (7.3) | 2 (0.9) | 16 (4) |
| UTVR+ | 6 (5) | 4 (3.6) | 2 (0.9) | 12 (3) |
| MR/T+ | 0 (0) | 2 (1.8) | 0 (0) | 2 (0.4) |
| ARF | 4 (3) | 3 (2.7) | 2 (0.9) | 9 (2) |
| SSH+ | 18 (16) | 2 (1)§ | 0 (0) | 20 (5) |
| E-CS+ | 8 (7) | 6 (5)§ | 0 (0) | 14 (3.2) |
| Death | 9 (7.9) | 5 (4.4)§ | 5 (3.2)§ | 19 (4.4) |

†P < 0.05, ‡P < 0.01 vs NR; §P < 0.01 vs primary coronary intervention (PCI); ¶P < 0.01 vs classe B; †P < 0.01 vs classe C. NR: Not send to reperfusion; TT: Transthoracic; AVB: Atrio-ventricular block requiring pacing; SVT: Sustained ventricular tachycardia; VF: Ventricular fibrillation; AF: Atrial fibrillation; PAT: Paroxysmal atrial tachycardia; R-MI: Reinfarction of the myocardium; UTVR: Urgent target vessel revascularization; MR/T: Myocardial rupture/tamponade; ARF: Acute renal failure; SSH: Sustained systemic hypotension (lasting < 12-24 h reversed with volume infusion and inotropic support); E-CS: Evolution to cardiogenic shock; +: Considered to be major cardiac complications.

Reversible RVWMA at 24-48 h with successful reperfusion was observed for classes A, B, and C patients in 84%, 78%, and 69%, respectively. Reversible RVF (defined as the normalization of the SSP without volume infusion or inotropic agents and/or improvement or normalization of RVWMA and RV dilatation by echocardiography) was documented for class B in 83% and for CS in 43% (Table 5).

Outcome

Class A: Half of the patients had uneventful clinical courses, although 3.2% developed CS, and 4.4% died. Hemodynamic data recorded at 48-72 h in 134 patients with or without successful reperfusion did not show any significant changes compared to baseline hemodynamics measurements. For those patients who received con-}

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Outcome

Class A: Half of the patients had uneventful clinical courses, although 3.2% developed CS, and 4.4% died. Hemodynamic data recorded at 48-72 h in 134 patients with or without successful reperfusion did not show any significant changes compared to baseline hemodynamics measurements. For those patients who received con-
This class is the only RVI category in which the following procedures in each RVI classes. Thus, our discussion for RVI primary reperfusion in early outcomes and late mortality among the 3 RVI classes. Our findings indicate that there are significant differences between the two strategies (P < 0.01) (Table 6).

Class C: When PPCI was successful, decreased ventricular arrhythmias, mRAP, RVEDP, mPWP and sPAP were found to be associated with an increased CI and mSAP. Without RT, the in-hospital mortality rate was 80%. With TT, the rate was 100%, and with PPCI, the rate was reduced to 44% (P < 0.01) (Table 6).

Mortality analysis
To establish the likelihood of mortality, clinical, echocardiographic and hemodynamic variables were tested. When submitted to stepwise logistic regression analysis, age 64-74 years (OR = 5.1; 95%CI: 1.9-14.1, P < 0.01), age ≥ 75 years (OR = 24.2; 95%CI: 7.1-71.6, P < 0.001), SSP < 100 mmHg (OR = 7.7; 95%CI: 2.4-19.1, P < 0.001) and classes B and C (OR = 38.6; 95%CI: 11.5-97.4, P < 0.01) were independent, significant predictors of mortality in the multivariate model.

A progressive increase in long-term mortality was noted for all of the RVI patients. At 8 years, without primary reperfusion, the mortality rate was 32% in class A patients, 48% in class B patients and 85% in class C patients (solid lines). When PPCI was successful, the mortality rate at 8 years was lower than previously observed for each RVI classes (21% for A, 38% for B, and 70% for C, P < 0.001, dashed lines) (Figure 2).

DISCUSSION
Our findings indicate that there are significant differences in early outcomes and late mortality among the 3 RVI classes. Thus, our discussion for RVI primary reperfusion treatment will focus on the results of reperfusion procedures in each RVI classes.

Class A
This class is the only RVI category in which the following question can be raised: Which is best for treating RVI: TT, PPCI or neither? The query was based on the supposition that (1) many RCA occlusions do not result in significant necrosis or RV dysfunction; (2) some thrombolytic studies have suggested little or no benefit in the absence of RVF; and (3) there are no controlled trials in any category of RVI with TT or PPCI.

Nevertheless, more than 40% of class A RVI patients presented at least one major in-hospital complication. Clinical and life threatening risks of an initially hemodynamically silent RVI can not be dismissed when considering timely RT. Although both reperfusion procedures decreased in-hospital mortality in A class RVI patients, our findings suggest that all patients with a hemodynamically silent RVI should undergo PPCI (when available).

Class B
Successful reperfusion of the RCA was associated with near normalization of the mRAP and RVEDP, improvement in the CO and mSAP and reversal of RVWMA/RVF in 78% and 83%. For this category of RVI patients our results demonstrate superior outcomes using PPCI over TT, based on following observations: (1) TIMI 3 RCA flow was obtained with TT in 64% and with PPCI in 91% of the patients; (2) more major complications such as AVB and ventricular arrhythmias, were observed using TT; and (3) mortality was lower in the PPCI treated patients compared to the TT-treated patients (13% vs 9%, P < 0.01).

Class C
The higher mortality in CS patients resulted from the substantial myocardial damage reflected by the more severe abnormalities in the RV hemodynamic measurements compared to those for class B patients. These findings are also consistent with the subset of patients who were likely to have suffered concomitant severe RA and RV ischemic dysfunction and, as expected, presented with major cardiac complications.

However, with PPCI we demonstrated a significant reduction in mortality (44%) due to (1) restored perfusion of the RCA and its major branches (TIMI 3 flow: 87%); and reversal of RVWMA (69%); (2) reduced mRAP, RVEDP and mPWP and increased CO and mSAP; and (3) a significant decrease in ventricular arrhythmias.

The mortality with PPCI in our study was lower than that in the SHOCK Registry (53%), but was higher compared to the study by Brodie et al in 30 patients (23%). When we compared Brodie’s results with ours, there are close similarities in age, door-to-balloon time, IABP support, stent use and TIMI grade 3-flow after PPCI. However, two important differences were noted. Although twice as many of our patients were sent for PPCI and could make our population more representative of RVI shock patients, the time from the first symptom to reperfusion was twice as long as Brodie’s study.

Prognosis
In our study, we found that the long-term mortality rate
continued to increase after the first year and was different for the 3 RVI classes. The differences in long-term survival after RVI in the 3 classes in our study could be due to coronary artery disease progression to complete RCA obstruction, significant LAD disease and/or poorly developed collateral coronary circulation, conditions that are most frequently observed in class B and C RVI patients. Perhaps the most important factors affecting outcome were the success or failure of the RT.

A study limitation
The major limitation; this analysis used nonrandomized, prospective surveillance and retrospective analysis; thus identified and unidentified confounders may have influenced the trends in reperfusion over time and clinical outcomes. Therefore, it is only an observational study. Nevertheless, this study reports results of RT over time in a large number of patients in 3 RVI categories and the information should be useful in current clinical practice.

In conclusion, PPCI seems to be superior to TT and reduces short and long-term mortality for all 3 RVI categories. Patients in CS should be encouraged to undergo PPCI rather than TT, as a primary reperfusion procedure; consequently, these patients should be transferred to a primary coronary intervention center to decrease the high morbidity and mortality of RVI class C patients.

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COMMENTS

Background
Right ventricular infarction (RVI) is relatively common in patients with acute inferior-posterior left ventricular myocardial infarction. RVI can depress right ventricular (RV) function, resulting in right ventricular failure (RVF) or cardiogenic shock (CS). There are scarce and somewhat conflicting clinical data concerning the effects of interventions designed to achieve reperfusion of the RV myocardium in acute ischemia.

Research frontiers
Several investigators have suggested that RV function improves only after successful thrombolytic therapy (TT), whereas others have reported recovery in the absence of early or even any reperfusion of the right coronary artery (RCA). In a study involving limited number of patients, rapid hemodynamic improvement and excellent clinical outcomes have been reported after successful primary percutaneous coronary intervention (PPCI) of the RCA and its major RV branches. Authors demonstrate that PPCI seems to be superior to TT and reduces short and long-term mortality for all 3 RVI categories. Patients in CS should be encouraged to undergo PPCI rather than TT, as a primary reperfusion procedure.

Innovations and breakthroughs
The findings indicate that there are significant differences in early outcomes and late mortality among the 3 RVI classes. Two important differences were noted. Although twice as many of our patients were sent for PPCI and could make the authors population more representative of RVI shock patients.

Applications
They found that the most important factors affecting outcome were the success or failure of the reperfusion. PPCI seems to be superior to TT and reduces short and long-term mortality for all 3 RVI categories. Patients in CS should be encouraged to undergo PPCI rather than TT, as a primary reperfusion procedure; consequently, these patients should be transferred to a primary coronary inter-

vention (PCI) center to decrease the high morbidity and mortality. The authors consider that their findings must be taken into consideration to be included in treatment guidelines for the RVI.

Terminology
The diagnosis of RVF was based on clinical features, including persistent systemic hypotension (systemic systolic pressure < 100 mmHg, right-sided S3 and S4) without features of shock, echocardiographic evidence of ischemic RVF (RV wall motion abnormalities associated with gross RV dilatation), findings that suggest globally depressed RV function and invasive hemodynamic monitoring identifying RVF by a combination of findings that suggest RV dysfunction (low cardiac output and a disproportionate elevation of the mean right atrial pressure compared to the mean pulmonary wedge pressure).

Peer review
This study investigated the impact of reperfusion therapy by means of primary PCI on clinical outcomes in acute RV infarction comparing with TT. The authors concluded that primary PCI is superior to TT and reduces the short-and-long-term mortality. The results are interesting and provide important impact on clinical practice.

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