Patterns of Use of Angiotensin-Converting Enzyme Inhibitors/Angiotensin Receptor Blockers Among Patients With Acute Myocardial Infarction in China From 2001 to 2011: China PEACE-Retrospective AMI Study

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Background—Chinese and U.S. guidelines recommend angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin receptor blockers (ARBs) for all patients with acute myocardial infarction (AMI) in the absence of contraindications as either a Class I or Class IIa recommendation. Little is known about the use and trends of ACEI/ARB therapy in China over the past decade.

Methods and Results—Using nationally representative data from the China Patient-centered Evaluative Assessment of Cardiac Events Retrospective Study of Acute Myocardial Infarction (China PEACE-Retrospective AMI Study), we assessed use of ACEI/ARB therapy in 2001, 2006, and 2011, overall and across geographic regions and strata of estimated mortality risk, and predictors of ACEI/ARB therapy, among patients with Class I indication by Chinese guidelines. The weighted rate of ACEI/ARB therapy increased from 62.0% in 2001 to 71.4% in 2006, decreasing to 67.6% in 2011. Use was low across all 5 geographic regions. By strata of estimated mortality risk, in 2001, rates of therapy increased with increasing risk; however, by 2011, this reversed and those at higher risk were less likely to be treated (70.7% in lowest-risk quintile vs. 63.5% in the highest-risk quintile; P<0.001).

Conclusion—One third of Chinese AMI patients with Class I indications do not receive ACEI/ARB therapy during hospitalization, with little improvement in rates over time. Patients at higher mortality risk in 2011 were less likely to be treated, highlighting important opportunities to optimize the use of this cost-effective therapy.

Clinical Trial Registration—URL: ClinicalTrials.gov. Unique identifier: NCT01624883. (J Am Heart Assoc. 2015;4:e001343 doi: 10.1161/JAHA.114.001343)
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Abstract

**Background**- Chinese and U.S. guidelines recommend angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin receptor blockers (ARBs) for all patients with acute myocardial infarction (AMI) in the absence of contraindications as either a Class I or Class IIa recommendation. Little is known about the use and trends of ACEI/ARB therapy in China over the past decade.

**Methods and Results**- Using nationally representative data from the China Patient-centered Evaluative Assessment of Cardiac Events Retrospective Study of Acute Myocardial Infarction (China PEACE-Retrospective AMI Study), we assessed use of ACEI/ARB therapy in 2001, 2006, and 2011, overall and across geographic regions and strata of estimated mortality risk, and predictors of ACEI/ARB therapy, among patients with Class I indication by Chinese guidelines. The weighted rate of ACEI/ARB therapy increased from 62.0% in 2001 to 71.4% in 2006, decreasing to 67.6% in 2011. Use was low across all 5 geographic regions. By strata of estimated mortality risk, in 2001, rates of therapy increased with increasing risk; however, by 2011, this reversed and those at higher risk were less likely to be treated (70.7% in lowest-risk quintile vs. 63.5% in the highest-risk quintile; P<0.001).

**Conclusion**- One third of Chinese AMI patients with Class I indications do not receive ACEI/ARB therapy during hospitalization, with little improvement in rates over time. Patients at higher mortality risk in 2011 were less likely to be treated, highlighting important opportunities to optimize the use of this cost-effective therapy.
Figure 1. Study sample profile. ACEI indicates angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; ARB, angiotensin receptor blocker.
Figure 2. Temporal trends in ACEI/ARB therapy by Chinese Class I and IIa, and ACC/AHA Class I and IIa. ACC/AHA indicates American College of Cardiology/American Heart Association; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.
| Characteristics                              | Total (%) (N=13,486) | Received ACEI/ARB (%) (N=9008) | Did not Receive ACEI/ARB (%) (N=4478) | P Value |
|---------------------------------------------|----------------------|-------------------------------|--------------------------------------|---------|
| **Demographic**                             |                      |                               |                                      |         |
| Age, y                                       |                      |                               |                                      |         |
| <55                                         | 22.2                 | 21.6                          | 23.4                                 | 0.16    |
| 55 to 64                                     | 23.7                 | 23.8                          | 23.3                                 |         |
| 65 to 74                                     | 30.1                 | 30.4                          | 29.6                                 |         |
| ≥75                                         | 24.0                 | 24.1                          | 23.7                                 |         |
| **Gender**                                  |                      |                               |                                      | 0.30    |
| Male                                        | 69.9                 | 70.2                          | 69.3                                 |         |
| Female                                       | 30.1                 | 29.8                          | 30.7                                 |         |
| **Cardiovascular risk factors**              |                      |                               |                                      |         |
| Hypertension                                 | 52.4                 | 60.4                          | 36.4                                 | <0.001  |
| Diabetes                                     | 20.6                 | 22.5                          | 16.9                                 | <0.001  |
| Current smoker                               | 34.9                 | 35.3                          | 34.1                                 | 0.15    |
| **Medical history**                          |                      |                               |                                      |         |
| Stroke                                       | 11.5                 | 11.9                          | 10.8                                 | 0.07    |
| Chronic renal insufficiency                  | 1.9                  | 1.9                           | 1.8                                  | 0.68    |
| Coronary heart disease                       | 22.6                 | 23.5                          | 20.6                                 | <0.001  |
| Myocardial infarction                        | 10.8                 | 11.4                          | 9.7                                  | 0.003   |
| Characteristics                                      | Total (%) (N=13,486) | Received ACEI/ARB (%) (N=9008) | Did not Receive ACEI/ARB (%) (N=4,478) | P Value |
|------------------------------------------------------|----------------------|---------------------------------|----------------------------------------|---------|
| Clinical characteristics during hospitalization      |                      |                                 |                                        |         |
| AMI type                                             |                      |                                 |                                        |         |
| Anterior STEMI                                       | 42.4                 | 44.6                            | 37.9                                   | <0.001  |
| Non-anterior STEMI                                   | 45.8                 | 42.4                            | 52.7                                   |         |
| NSTEMI                                               | 11.8                 | 13.0                            | 9.4                                    |         |
| Cardiac arrest                                       | 2.8                  | 2.6                             | 3.1                                    | 0.09    |
| Cardiogenic shock                                    | 6.2                  | 5.0                             | 8.6                                    | <0.001  |
| Heart failure                                        | 34.6                 | 37.3                            | 29.0                                   | <0.001  |
| Atrial fibrillation                                  | 9.4                  | 9.5                             | 9.3                                    | 0.63    |
| SBP, mm Hg                                           |                      |                                 |                                        | <0.001  |
| <90                                                  | 4.1                  | 2.4                             | 7.4                                    |         |
| 90 to 139                                            | 58.5                 | 53.8                            | 68.2                                   |         |
| ≥140                                                 | 37.4                 | 43.8                            | 24.4                                   |         |
| Heart rate, beats/min                                |                      |                                 |                                        | <0.001  |
| <60                                                  | 12.3                 | 10.8                            | 15.3                                   |         |
| 60 to 90                                             | 65.8                 | 66.3                            | 64.7                                   |         |
| >90                                                  | 22.0                 | 22.9                            | 20.1                                   |         |
| eGFR, mL/min per 1.73 m²                             |                      |                                 |                                        | <0.001  |
| <60                                                  | 16.6                 | 14.3                            | 21.1                                   |         |
| 60 to 89                                             | 26.1                 | 23.7                            | 31.1                                   |         |
| ≥90                                                  | 24.8                 | 22.7                            | 29.0                                   |         |
| Unmeasured                                           | 32.5                 | 39.4                            | 18.8                                   |         |
| Characteristics                        | Total (%) (N=13,486) | Received ACEI/ARB (%) (N=9,008) | Did not Receive ACEI/ARB (%) (N=4,478) | P Value |
|---------------------------------------|-----------------------|---------------------------------|----------------------------------------|---------|
| LVEF value                            |                       |                                 |                                        |         |
| \( \leq 0.40\)                        | 7.0                   | 7.7                             | 5.5                                    | <0.001  |
| >0.40                                 | 41.6                  | 46.0                            | 32.7                                   |         |
| Unmeasured                            | 51.4                  | 46.3                            | 61.7                                   |         |
| **Economic-geographic region**        |                       |                                 |                                        |         |
| Eastern                               | 59.2                  | 58.7                            | 60.2                                   | 0.10    |
| Central                               | 21.2                  | 21.2                            | 21.2                                   |         |
| Western                               | 19.6                  | 20.1                            | 18.6                                   |         |
| **Rural/urban**                       |                       |                                 |                                        |         |
| Rural                                 | 38.8                  | 38.1                            | 40.2                                   | 0.02    |
| Urban                                 | 61.2                  | 61.9                            | 59.8                                   |         |
| **Hospital characteristics**          |                       |                                 |                                        |         |
| Teaching                              | 80.3                  | 82.3                            | 76.3                                   | <0.001  |
| PCI-capable                           | 60.8                  | 63.4                            | 55.5                                   | <0.001  |
| **Year**                              |                       |                                 |                                        | <0.001  |
| 2001                                  | 15.1                  | 13.9                            | 17.7                                   |         |
| 2006                                  | 28.5                  | 29.9                            | 25.9                                   |         |
| 2011                                  | 56.3                  | 56.3                            | 56.4                                   |         |

ACEI indicates angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; ARB, angiotensin receptor blocker; eGFR, estimated glomerular filtration rate; LVEF, left ventricular ejection fraction; NSTEMI, non-ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; SBP, systolic blood pressure; STEMI, ST-segment elevation myocardial infarction.

*The number (N) reflects the number of patients who were admitted to hospitals with this characteristic.
| Characteristics                      | Chinese Class I Patients (%) (N=13,486) | Patients With Length of Stay <24 Hours (%) (N=1123) | P Value |
|-------------------------------------|----------------------------------------|-------------------------------------------------|---------|
| **Demographics**                    |                                        |                                                 |         |
| Age, y                              |                                        |                                                 | <0.001  |
| <55                                 | 22.2                                   | 16.7                                            |         |
| 55 to 64                            | 23.7                                   | 19.2                                            |         |
| 65 to 74                            | 30.1                                   | 31.2                                            |         |
| ≥75                                 | 24.0                                   | 32.9                                            |         |
| Gender                              |                                        |                                                 | <0.001  |
| Male                                | 69.9                                   | 60.6                                            |         |
| Female                              | 30.1                                   | 39.4                                            |         |
| **Cardiovascular risk factors**     |                                        |                                                 |         |
| Hypertension                        | 52.4                                   | 40.7                                            | <0.001  |
| Diabetes                            | 20.6                                   | 17.7                                            | 0.02    |
| Current smoker                      | 34.9                                   | 13.2                                            | <0.001  |
| **Medical history**                 |                                        |                                                 |         |
| Stroke                              | 11.5                                   | 11.4                                            | 0.92    |
| Chronic renal insufficiency         | 1.9                                    | 2.7                                             | 0.05    |
| Coronary heart disease              | 22.6                                   | 19.2                                            | 0.01    |
Table 2. Continued

| Characteristics                      | Chinese Class I Patients (%) (N=13,486) | Patients With Length of Stay < 24 Hours (%) (N=1,123) | P Value |
|--------------------------------------|-----------------------------------------|-------------------------------------------------------|---------|
| Myocardial infarction                | 10.8                                    | 8.3                                                   | 0.008   |
| Clinical characteristics during hospitalization |                                        |                                                       |         |
| AMI type                             |                                         |                                                       | 0.001   |
| Anterior STEMI                       | 42.4                                    | 47.8                                                  |         |
| Non-anterior STEMI                   | 45.8                                    | 40.5                                                  |         |
| NSTEMI                               | 11.8                                    | 11.7                                                  |         |
| Cardiac arrest                       | 2.8                                     | 18.9                                                  | <0.001  |
| Cardiogenic shock                    | 6.2                                     | 35.4                                                  | <0.001  |
| Heart failure                        | 34.6                                    | 37.4                                                  | 0.06    |
| Atrial fibrillation                  | 9.4                                     | 9.7                                                   | 0.77    |
| SBP, mm Hg                           |                                         |                                                       | <0.001  |
| < 90                                 | 4.1                                     | 24.6                                                  |         |
| 90 to 139                            | 58.5                                    | 52.2                                                  |         |
| ≥ 140                                | 37.4                                    | 23.2                                                  |         |
| Heart rate, beats/min                |                                         |                                                       | <0.001  |
| < 60                                 | 12.3                                    | 17.7                                                  |         |
| 60 to 90                             | 65.8                                    | 47.8                                                  |         |
| > 90                                 | 22.0                                    | 34.5                                                  |         |
| eGFR, mL/min per 1.73 m²             |                                         |                                                       | <0.001  |
| < 60                                 | 16.6                                    | 28.6                                                  |         |
| 60 to 89                             | 26.1                                    | 18.4                                                  |         |
| ≥ 90                                 | 24.8                                    | 11.1                                                  |         |
| Unmeasured                           | 32.5                                    | 41.9                                                  |         |
Table 2. Continued

| Characteristics                      | Chinese Class I Patients (%) (N=13,486) | Patients With Length of Stay <24 Hours (%) (N=1123) | P Value |
|--------------------------------------|----------------------------------------|---------------------------------------------------|---------|
| LVEF value                           |                                        |                                                   | <0.001  |
| ≤0.40                                | 7.0                                    | 1.5                                               |         |
| >0.40                                | 41.6                                   | 2.5                                               |         |
| Unmeasured                           | 51.4                                   | 96.0                                              |         |
| Economic-geographic region           |                                        |                                                   |         |
| Eastern                              | 59.2                                   | 55.8                                              | 0.03    |
| Central                              | 21.2                                   | 24.3                                              |         |
| Western                              | 19.6                                   | 19.9                                              |         |
| Rural/urban                          |                                        |                                                   |         |
| Rural                                | 38.8                                   | 53.8                                              | <0.001  |
| Urban                                | 61.2                                   | 46.2                                              |         |
| Hospital characteristics*            |                                        |                                                   |         |
| Teaching                             | 80.3                                   | 72.6                                              | <0.001  |
| PCI-capable                          | 60.8                                   | 48.1                                              | <0.001  |
| Year                                 |                                        |                                                   |         |
| 2001                                 | 15.1                                   | 9.0                                               | <0.001  |
| 2006                                 | 28.5                                   | 27.0                                              |         |
| 2011                                 | 56.3                                   | 64.0                                              |         |

AMI indicates acute myocardial infarction; eGFR, estimated glomerular filtration rate; LVEF, left ventricular ejection fraction; NSTEMI, non-ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; SBP, systolic blood pressure; STEMI, ST-segment elevation myocardial infarction.

*The number (N) reflects the number of patients who were admitted to hospitals with this characteristic.
Table 3. The Proportion of Patients With Length of Stay Less Than 24 Hours Receiving ACEI/ARB Therapy

| Patients | Died (N=500) | Transferred Out (N=297) | Discharged (N=326) |
|----------|--------------|-------------------------|--------------------|
| ACEI/ARB | 20.8%        | 32.0%                   | 27.6%              |

ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.
Table 4. The Weighted Proportion of ACEI/ARB Therapy in Patients With Creatinine <1.5 and ≤3.0 mg/dL by Year by Chinese Class I and Class IIa

| Cr Value | Patients     | Received ACEI/ARB, % (95% CI) | 2001       | 2006       | 2011       | P for Trend |
|----------|--------------|--------------------------------|------------|------------|------------|-------------|
| Cr<1.5   | Chinese Class I | 62.4 (60.2 to 64.6)             | 72.5 (71.0 to 74.0) | 68.5 (67.4 to 69.6) | <0.01       |
|          | Chinese Class IIa | 36.5 (23.0 to 50.0)             | 37.4 (26.2 to 48.6) | 48.1 (42.1 to 54.1) | 0.06        |
| Cr≤3.0   | Chinese Class I  | 62.0 (59.9 to 64.1)             | 71.4 (70.0 to 72.8) | 67.6 (65.5 to 68.6) | 0.01        |
|          | Chinese Class IIa | 38.6 (32.0 to 45.3)             | 38.9 (33.3 to 44.4) | 47.9 (44.9 to 50.9) | 0.1         |

ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; Cr, creatinine.
Figure 3. Use of ACEI, ARB, and both ACEI/ARB among Chinese Class I patients by year. ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.
Figure 4. A, ACEI prescription among eligible patients by year. B, ARB prescription among eligible patients by year. ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.
Figure 5. Regional trends in ACEI/ARB use among Chinese Class I patients by year. ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; C/WU, central/western-urban; CR, central-rural; ER, eastern-rural; EU, eastern-urban; WR, western-rural.
Figure 6. Factors associated with ACEI/ARB use among Chinese Class I patients in multivariable analysis. Variables associated with ACEI/ARB use are shown along the vertical axis. The strength of effect is shown along the horizontal axis with the vertical line demarcating an odds ratio (OR) of 1 (i.e., no association); estimates to the right (i.e., >1) are associated with a greater likelihood of ACEI/ARB use, whereas those to the left (i.e., <1) indicate a reduced likelihood of ACEI/ARB use. Each dot represents the point estimate of the effect of that variable in the model, whereas the line shows the 95% confidence interval (CI). C-statistic=0.75. ACEI indicates angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; ARB, angiotensin receptor blocker; eGFR, estimated glomerular filtration rate; LVEF, left ventricular ejection fraction; NSTEMI, non-ST-segment elevation myocardial infarction; SBP, systolic blood pressure; STEMI, ST-segment elevation myocardial infarction.
Figure 7. A, ACEI/ARB use among Chinese Class I patients by year stratified by estimated in-hospital mortality risk. P for trend. P for year x mortality risk interaction <0.001. C-statistic=0.77. B, ACEI/ARB use among Chinese Class I patients after excluding BP <90 mmHg by year stratified by estimated in-hospital mortality risk. P for trend. P for year x mortality risk interaction <0.001. C-statistic= 0.76. ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; BP, blood pressure.
Conclusion

• In this nationally representative study of patients hospitalized with AMI in China, we found underutilization of ACEI/ARB therapy, which extends across regions, and rates of use have not improved appreciably over the past decade.
• Moreover, with time, a risk treatment paradox has emerged, wherein there is considerable underuse of ACEI/ARB among subgroups at the highest risk for mortality.
• These findings identify important opportunities for improvement as the Chinese health-care system reengineers itself to deliver high-quality care to the rising number of people with AMI.
• These data can serve as a baseline against which future improvements can be measured.