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Identifying and Solving Gaps in Pre- and In-Hospital Acute Myocardial Infarction Care in Asia-Pacific Countries

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AUTHOR'S SUMMARY

Acute myocardial infarction (AMI) morbidity and mortality differs between Asia-Pacific countries and is contributed to by differences in systems of care. This article elaborates on how systems of care can be improved. Suggestions include: 1) Patient education on AMI symptoms and need to activate emergency medical services (EMS); 2) Developing robust, centralized and well-coordinated EMS; 3) Performing pre-hospital electrocardiogram with onward transmission and video telemedicine triage; 4) Setting up geographically oriented ST elevation myocardial infarction networks; 5) Employing algorithms to diagnose high-risk AMI; 6) Adhering to clinical practice guidelines and integrated care pathways; 7) Creating AMI registries and auditing outcomes.

ABSTRACT

Acute myocardial infarction (AMI) is a major cause of morbidity and mortality in the Asia-Pacific region, and mortality rates differ between countries in the region. Systems of care have been shown to play a major role in determining AMI outcomes, and this review aims to highlight pre-hospital and in-hospital system deficiencies and suggest possible improvements to enhance quality of care, focusing on Korea, Japan, Singapore and Malaysia as representative countries. Time to first medical contact can be shortened by improving patient awareness of AMI symptoms and the need to activate emergency medical services (EMS), as well as by developing robust, well-coordinated and centralized EMS systems. Additionally, performing and transmitting pre-hospital electrocardiograms, algorithmically identifying patients with high risk AMI and developing hospital networks that appropriately divert such patients to percutaneous coronary intervention-capable hospitals have been shown to be beneficial. Within the hospital environment, developing and following clinical practice guidelines ensures that treatment plans can be standardised, whilst integrated care pathways can aid in coordinating care within the healthcare institution and can guide care even after discharge. Prescription of guideline directed medical therapy for secondary prevention and patient compliance to medications can be further optimised. Finally, the authors advocate for the establishment of more regional, national and international AMI registries for the formal collection of data to facilitate audit and clinical improvement.

Keywords: Acute myocardial infarction; Pre-hospital care; Healthcare systems; Asia-Pacific

INTRODUCTION

Acute myocardial infarction (AMI) remains a major cause of morbidity and mortality in the Asia-Pacific region,[1] with mortality often exceeding that of developed western countries.[2] The Asia-Pacific region is heterogenous, with a large diversity of ethnicities, cultures, income levels, systems of care and healthcare spending in its constituent countries.

Accordingly, mortality rates from AMI differ, with the gap arguably starkest between high-income and middle/low-income countries. Whilst mortality rates from ischemic heart disease and cardiovascular disease in general have declined over the past 3 decades in the subset of high-income Asia-Pacific countries,[3][4] this trend is reversed when considering the entirety of Asia as a whole (**Figure 1**). Comparing mortality rates of individual countries across the same period also reveals considerable differences.

These differences are driven by a multiplicity of factors, some of which may not be readily amenable to intervention (e.g., ethnic composition). Nevertheless, systems of care have been shown to play a significant role in determining AMI outcomes, particularly in the context of ST elevation myocardial infarction (STEMI),[5][6] and represent an important target for intervention and improvement.

Whilst by no means comprehensive, this narrative review represents the authors' take on gaps in pre- and in-hospital AMI care in Asia-Pacific (**Figure 2**). The aim is to highlight present system deficiencies and suggest possible improvements to enhance quality of care. We have chosen to focus on Korea, Japan, Singapore and Malaysia as representative countries given their availability of data.
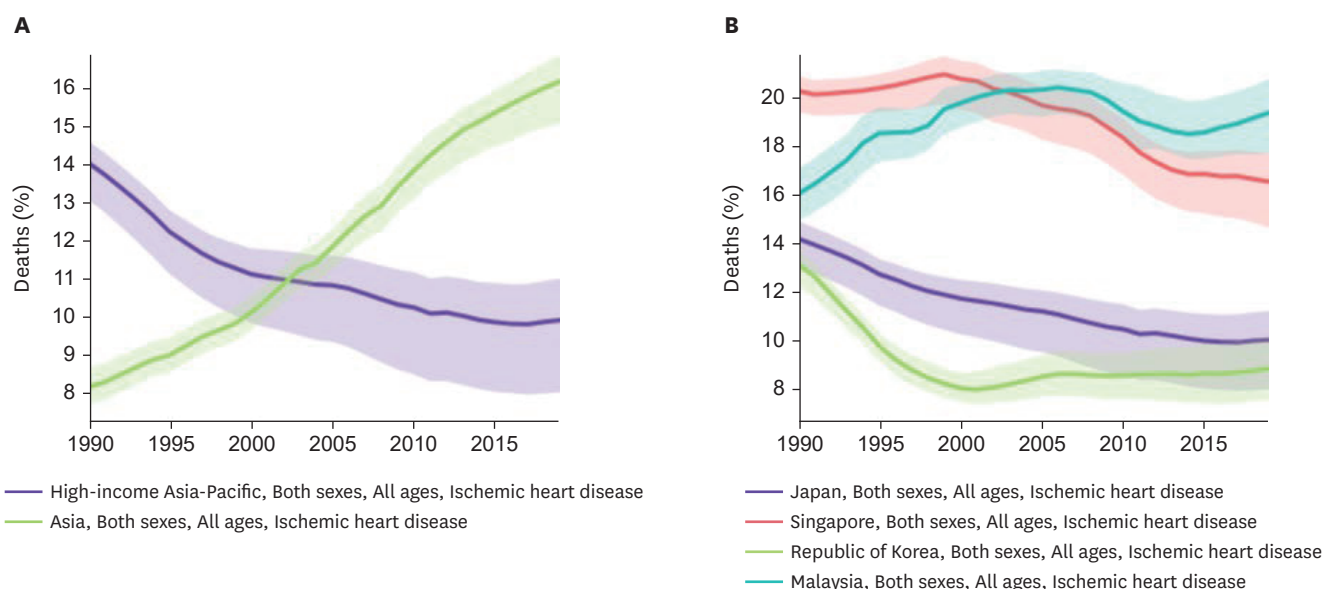

Figure 1. (A) Mortality rate of ischaemic heart disease in Asia versus only high-income Asia-Pacific countries, 1990–2019. (B) Morality rate of ischaemic heart disease in Japan, Singapore, Republic of Korea and Malaysia, 1990–2019. Lighter areas represent 95% confidence intervals for estimates. Data based on the Global Burden of Disease Study 2019.[3]
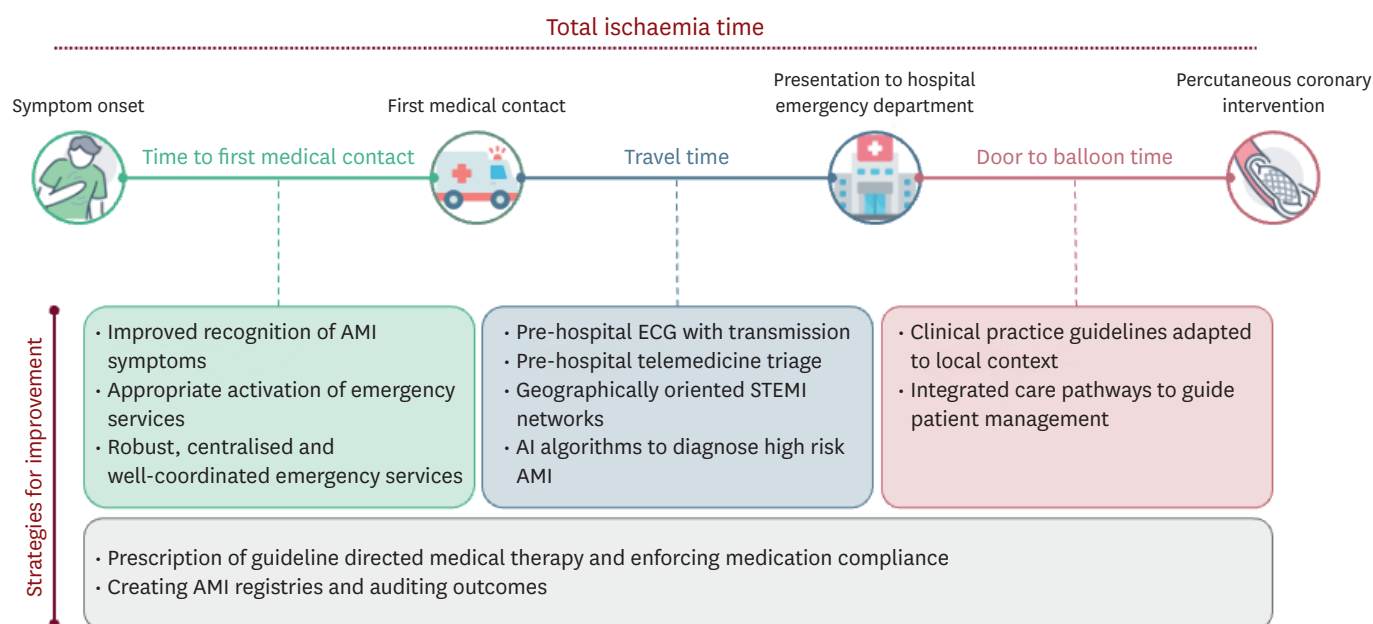
Figure 2. Summary of suggestions for improvement to reduce ischaemia time and improve AMI care.
AI = artificial intelligence; AMI = acute myocardial infarction; ECG = electrocardiogram; STEMI = ST elevation myocardial infarction.

PRE-HOSPITAL CARE

Prompt and accurate diagnosis and intervention is important in AMI; nowhere more so than in cases of STEMI where "time is myocardium."[7] Every minute of delay in treatment of STEMI results in worse mortality outcomes.[8)9] This introduces the concept of total ischemic time (TIT), which comprises both patient delays and systemic delay. Patient delays occur when time is lost between symptom onset and first medical contact (FMC), whilst systemic delays represent the subsequent time taken by healthcare systems to make a diagnosis of STEMI, triage patients to appropriate centers and achieve reperfusion. Both patient delays and systemic delays can and should be optimized to reduce TIT, and this is reflected in the latest European Society of Cardiology (ESC) guidelines on STEMI management.[10] Pre-hospital care can be enhanced by reducing time to FMC, improving emergency medical services (EMS), employing pre-hospital 12-lead electrocardiograms (ECGs) and building STEMI networks that allow patients to be right-sited to percutaneous coronary intervention (PCI) capable hospitals.

Time to first medical contact

Time to FMC is primarily affected by the ability of patients to recognize AMI symptoms and seek medical attention. Often, activating EMS represents the most expedient way of obtaining medical assistance, and the public should be educated on calling for an ambulance if they identify AMI symptoms. Nevertheless, public awareness of AMI symptoms and the need to activate EMS remains suboptimal, as captured by nationwide surveys.

In a nationwide survey of 9,600 residents in Korea, 88.7% knew ≥1 symptom but only 10.9% knew all 5 symptoms of AMI. The 67% would call an ambulance if someone showed signs of AMI.[11] A similar survey using the Korean Community Health Survey involving 228,281 participants found that only 42.4% were aware of MI symptoms.[12] A Malaysian survey of 393 respondents found that 11.5% recognized all 5 AMI symptoms, 82% recognized ≥1 symptom and 35.6% would call an ambulance for AMI symptoms.[13] Meanwhile, a survey of 4,192

respondents in Singapore found that 57.8% were proficient in identifying AMI symptoms.[14] In Japan, only 11.6% of the 1,200 participants surveyed were aware of the need to call EMS promptly for AMI symptoms.[15] More broadly, a meta-analysis by Sharma et al.[16] reported a wide variation in the prevalence of awareness of chest pain as a symptom of MI in various Asian countries.

Amongst the abovementioned studies, a common risk factor for not identifying AMI symptoms was a low education level.[12)15)17] This may potentially be remediated by a national campaign on AMI symptoms and the need to activate EMS rapidly, especially given how effective the analogous "Act FAST" campaign has been in improving public awareness of stroke symptoms.[18]

Making use of emergency medical services

EMS use is associated with substantial reduction in treatment delays and TIT in STEMI,[19] and the ESC guidelines on STEMI recommend having an EMS with an easily recalled and well-publicized number.[10] Similar findings on the benefits of utilizing EMS have been reported in Asian studies, including significantly improved odds of symptom to door time <60 minutes in Korea[20] as well as shorter symptom-to-door time, door-to-ECG time, ECG-to-diagnosis time, door-to-balloon (DTB) time, and symptom-to-balloon time in Singapore.[21-23]

Given this, a robust and well-coordinated EMS system is imperative. Currently, both Korea and Japan have one-tiered ambulance-based EMS activated by the number "119." Singapore's EMS is administered by the Singapore Civil Defence Force via the number "995." In Malaysia, whilst the Ministry of Health remains the main provider of ambulance services, other agencies such as the St. John's Ambulance of Malaysia, Malaysian Red Crescent Society, Civil Defence, University Hospitals and private ambulance services also contribute. Consequently, in 2007 the Malaysian government established the Malaysia Emergency Response Service 999 system as well as the Medical Emergency Call Centre to coordinate ambulance services and EMS.[24] There remains considerable heterogeneity in EMS system set-up and maturity amongst Asia-Pacific countries.[25)26] Countries should consider amalgamating medical first-responder services under a centrally operated public EMS for ease of access.

Use of pre-hospital 12-lead electrocardiogram

One of the advantages of EMS activation over private transport to a healthcare facility is the opportunity to obtain an early 12-lead ECG. Guidelines suggest that EMS providers should be accountable for performing a pre-hospital ECG, making the diagnosis of STEMI and deciding whether or not to transport patients to a PCI-capable hospital.[10)27]

A nationwide rollout of 12-lead ECG recording and transmission by ambulance crews was undertaken in Singapore in 2008 and was associated with a significant improvement in DTB times in STEMI patients.[28] The National Heart Association of Malaysia Clinical Practice Guidelines for management of STEMI and non-ST elevation myocardial infarction (NSTEMI) also recommends performing and transmitting a 12-lead ECG that should be read in <10 minutes.[29]

Pre-hospital ECG has been shown to be beneficial in Japanese and Korean studies, but adoption remains limited and pre-hospital ECGs are not always performed by EMS staff.[30] In Busan, Korea, local implementation of a 12-lead ECG transmission system led to reductions in systemic time delay and DTB time.[31] Meanwhile, in Kanagawa, Japan, use of pre-hospital ECG was associated with reduced in-hospital mortality in addition to shorter DTB times.[32]

An alternative system employed "doctor car" systems where EMS providers initiated contact with patients before ambulance services arrived and performed a 12-lead ECG that was uploaded to the cloud, leading to improved DTB time.[33] The authors suggest that pre-hospital 12-lead ECGs should be conducted and transmitted routinely, leveraging the growing ubiquity of 4G and 5G networks.

Looking to the future, ambulance-to-hospital transmissions could be augmented even further by the use of telemedicine video consults whilst patients are still enroute, thereby allowing physicians in emergency departments to begin the process of assessment and triage early, especially when there is significant ambulance travel time. Such video consultation services have already been trialed in the context of stroke activations[34] and trauma.[35] One potential use case could be in the early assessment of patients with out of hospital cardiac arrest such that a decision can be made as to whether cardiac catheterisation laboratories activation is appropriate and required.

ST elevation myocardial infarction networks and appropriate triage

Early reperfusion, ideally via primary PCI, is the mainstay of STEMI management.[27] This requires transfer to a PCI-capable hospital should STEMI be diagnosed. Consequently, it makes sense to develop geographically oriented STEMI networks to facilitate timely transfer of patients.[10]

Such STEMI networks have been reliably instituted in Korea and Singapore. In Japan and Malaysia, the development of the Tokyo Cardiovascular Care Unit (CCU) network[36] and the MySTEMI network[37] in the respective countries has proven to be effective, especially in service of the populous capitals of Tokyo and Kuala Lumpur. However, these networks are less well established in more remote parts of these countries. Hub and spoke models have also been trialed, albeit to a limited extent, in other Asia-Pacific countries such as India[38] and China.[39] Future directions for AMI care in Asia-Pacific should include a nationwide commitment to developing trustworthy STEMI networks. Lessons can be learnt from Korea, where the government passed the Cardio-cerebrovascular Disease Prevention and Control Act in May 2017 that laid the legal frameworks for the establishment of regional treatment networks in the form of regional cardio-cerebrovascular centers, which have now translated to positive improvements in clinical outcomes.[40]

Appropriate transfer to PCI centers also necessitates accurate diagnosis of AMI (both STEMI and NSTEMI). In the future, artificial intelligence (AI)-based algorithms may aid EMS staff in identifying patients with AMI. AI algorithms based on symptoms, vital signs and symptoms have already achieved good performance[41] and shown to be helpful in triaging chest pain.[42] These algorithms have been applied to both STEMI[43] and NSTEMI[44] cases, with positive outcomes.

IN-HOSPITAL CARE

Hospitals are complex systems, and many factors affect the in-hospital care of AMI patients as well as their outcomes. These range from availability of facilities such as cardiovascular laboratories, to appropriate and timely use of pharmacological and invasive therapies, and are often constrained by local resources and funding. The authors would like to focus the scope of discussion to the use of standardized protocols and care pathways, optimizing medical therapy, and maintaining registries for quality improvement.

Local guidelines, standardized protocols and care pathways

Clinical practice guidelines provide an opportunity for standardizing treatment and establish an objective specification on how patients ought to be managed. Nevertheless, they ought to be adapted to the local context. The National Heart Association of Malaysia has developed Clinical Practice Guidelines in 2019 and 2021 for the management of STEMI[29] and NSTEMI,[45] respectively; the Japanese Circulation Society previously published guidelines on the treatment and diagnosis of acute coronary syndrome in 2018[46] and the Korean Society of Myocardial Infarction has put together expert consensus recommendations on pharmacotherapy[47] and revascularization[48] for AMI that take into account evidence gathered from Korean populations. Countries that do not have local guidelines may consider referring to those created by countries with similar patient demographics, in addition to American or European guidelines.

On a more practical level, healthcare teams can be better guided in their management of patients by integrated care pathways, which aim to translate guidelines into clearly laid out stepwise clinical processes that fit into the unique culture and system of a particular healthcare institution. When applied to AMI, care pathways have already been shown to reduce DTB time and length of stay.[49-51] A Korean study of 2 academic tertiary hospitals found that care pathways standardized patient care and negated time delays even when patients arrived out of hours or on weekends.[52] The positive effects of care pathways on clinical outcomes have also been replicated in studies in Hong Kong[53] and Pakistan.[54]

Additionally, discharge protocols can be employed to ensure that patients have been medically optimized prior to discharge, including being started on the appropriate guideline-directed medications. They can also be used to identify patients who are at low risk and may qualify for early discharge and as such a shorter length of stay.[55] These can be supplemented by written advice to patients regarding lifestyle changes, rules around driving, and gradual return to physical activity. The care pathways and protocols should extend beyond the index hospital admission and guide cardiac rehabilitation and follow-up. At present, there is overall poor uptake and compliance to these integrated care pathways, which represents an opportunity for improvement.[56]

Pharmacotherapy for secondary prevention

Typical medications for the secondary prevention of AMI include dual antiplatelet therapy (DAPT), lipid lowering therapy, Beta-blockers and angiotensin converting enzyme inhibitors (ACEi) or angiotensin receptor blockers (ARB). The Asia-Pacific Society of Cardiology and the Korean Society for Myocardial Infarction have summarized expert consensus on appropriate pharmacotherapy post AMI, integrating published European and American guidelines with contemporary studies involving Asian patients.[47)57]

Rates of in-hospital prescription of these medications have previously been summarized in a meta-analysis,[58] as well as in reported registry data.[59-65] Whilst prescription of DAPT and statins were often in excess of 90%, prescription of beta-blockers and ACEi/ARBs was far more inconsistent. Furthermore, the use of guideline-directed medical therapy declined with time.[66] Given that the use of guideline-directed medications has been shown to be inversely associated with mortality,[60] the authors recommend that attention be given to improving prescribing rates of these medications where not contraindicated, as well as to ensuring that patients remain compliant to medical therapy at follow-up.

Acute myocardial infarction registries drive audit and quality improvement

Finally, the authors recommend the establishment of more AMI registries for the purposes of audit and quality improvement. Experience from the Get With The Guidelines programme in the United States (US) has shown that registries are effective in driving guideline-concordant care over time in participating hospitals.[67]

A few voluntary AMI-based registries are present in Korea and Japan: for example, the Korea Acute Myocardial Infarction Registry,[59] the Korean Registry of Acute Myocardial Infarction for Regional Cerebrovascular Centers,[68] Japanese Registry of All Cardiac and Vascular Diseases Diagnosis Procedure Combination,[60] Japan Acute Myocardial Infarction Registry[69] and the registry from the Tokyo CCU network.[70] However, the abovementioned registries only involve a limited number of hospitals. In contrast, the Singapore Myocardial Infarction Registry (SMIR)[61] and the Malaysian National Cardiovascular Disease-Acute Coronary Syndrome Registry[71] are national, and of the 2 only the SMIR is compulsory and mandated by law. Other examples from Asia-Pacific countries include the Thai Acute Coronary Syndrome Registry[72] and the Clinical Pathways for Acute Coronary Syndromes in China Registry,[73] but in general few countries in Asia-Pacific maintain registries, and quality of data varies greatly.[74]

Formal collection of AMI data in the form of registries not only allow for audit and clinical improvement, but also provide insight into local AMI trends and can be used for research or to guide healthcare policy at the national level.[58,75] Comprehensiveness of dataset is thus important, and there may be an argument for government mandated nationwide registries. In any case, the authors advocate for the creation of internal registries with data sharing, common data structures and feedback between healthcare institutions, especially within regional STEMI networks. The Mission: Lifeline Accelerator Projects in the US showed that internal registries coupled with training, regional reports and leadership meetings was associated with improvements in treatment times and mortality, which was not apparent in hospitals that were not participating in the project.[76]

CONCLUSION

Whilst there has been significant progress in the treatment of AMI in Asia-Pacific over the past 2 decades, and especially in high income countries, there remains room for improvement (**Table 1**). Countries can learn from each other and adopt systems of care that have worked well in contemporaneous circumstances. In this review, we have suggested leveraging on centralized EMS to reduce pre-hospital delays, employing clinical guidelines and care pathways to standardize and streamline care, improving prescription rates of guideline-directed medical therapy and employing registries as data repositories for audit and research as areas to focus future efforts on.

Nonetheless, we recognize that AMI care is multidimensional, and there is much more that can be done that has not been captured in the discussion above. Furthermore, the scope of our discussion has centered mostly around a limited number of countries—and we appreciate that different challenges may be present in other Asia-Pacific countries, especially ones that operate in a setting of lower healthcare resources. It is our hope that with continued effort and endeavor, sustained progress can be made in improving AMI outcomes in the decade to come.

Table 1. Gaps in current AMI care and potential areas for improvement

Key gaps	Areas for improvement
· Public awareness of AMI symptoms and the need to activate EMS remains suboptimal. · A common risk factor for not identifying AMI symptoms is a low education level.	· Public education campaigns on AMI symptoms, how to recognise them and who to call.
· EMS in some countries are fragmented, resulting in patchy coverage and impairing access.	· Centralise and coordinate emergency services, with a single easily-remembered and well-publicised number for activation
· Not all countries employ pre-hospital ECGs, which can be used to diagnose STEMI which requires emergent revascularisation. · STEMI patients are sometimes conveyed to hospitals that may be geographically nearer but not PCI-capable.	· Performance of pre-hospital ECG, with transmission to hospital emergency departments such that cardiac catheterisation laboratories can be put on standby for immediate patient transfer. · Leverage telemedicine to allow pre-hospital video consultation for identification of high-risk AMI and appropriate triage. · Establish regional STEMI networks with specified catchment areas and coordinate with EMS to facilitate the prompt transfer of patients diagnosed with STEMI to PCI-capable hospitals for emergent revascularisation.
· Management of patients with AMI may differ between hospitals, based on local clinical capabilities.	· Develop clinical practice guidelines to standardise treatment and establish objective specifications on how AMI patients ought to be managed. · Make use of integrated care pathways tailored to the local healthcare context to translate guidelines into stepwise clinical processes and coordinate care delivery. · Utilise discharge protocols and care pathways to evaluate readiness for discharge and guide post-discharge follow up and rehabilitation.
· Patients are not always discharged on correct medications for secondary prevention of AMI.	· Focus on improving prescription of guideline-directed medical therapy and reinforce patient compliance.
· Lack of data and insight into AMI outcomes and trends at a national level. · Lack of data and insight into individual centre performance in delivering AMI care.	· Create registries for formal collection of data for audit and research purposes.

AMI = acute myocardial infarction; ECG = electrocardiogram; EMS = emergency medical services; PCI = percutaneous coronary intervention; STEMI = ST elevation myocardial infarction.

REFERENCES

1. Ohira T, Iso H. Cardiovascular disease epidemiology in Asia: an overview. *Circ J* 2013;77:1646-52.
   PUBMED | **CROSSREF**

2. Chan MY, Du X, Eccleston D, et al. Acute coronary syndrome in the Asia-Pacific region. *Int J Cardiol* 2016;202:861-9.
   PUBMED | **CROSSREF**

3. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020;396:1223-49.
   PUBMED | **CROSSREF**

4. Zhao D. Epidemiological features of cardiovascular disease in Asia. *JACC Asia* 2021;1:1-13.
   PUBMED | **CROSSREF**

5. Jacobs AK, Antman EM, Faxon DP, Gregory T, Solis P. Development of systems of care for ST-elevation myocardial infarction patients: executive summary. *Circulation* 2007;116:217-30.
   PUBMED | **CROSSREF**

6. Jacobs AK, Ali MJ, Best PJ, et al. Systems of care for ST-segment-elevation myocardial infarction: a policy statement from the American Heart Association. *Circulation* 2021;144:e310-27.
   PUBMED | **CROSSREF**

7. Gibson CM. Time is myocardium and time is outcomes. *Circulation* 2001;104:2632-4.
   PUBMED | **CROSSREF**

8. De Luca G, Suryapranata H, Ottervanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction: every minute of delay counts. *Circulation* 2004;109:1223-5.
   PUBMED | **CROSSREF**

9. Terkelsen CJ, Sørensen JT, Maeng M, et al. System delay and mortality among patients with STEMI treated with primary percutaneous coronary intervention. *JAMA* 2010;304:763-71.
   PUBMED | **CROSSREF**

10. Ibanez B, James S, Agewall S, et al. 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the task force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J* 2018;39:119-77.
   PUBMED | **CROSSREF**

11. Kim HS, Lee H, Kim K, et al. The general public's awareness of early symptoms of and emergency responses to acute myocardial infarction and related factors in South Korea: a national public telephone survey. *J Epidemiol* 2016;26:233-41.
PUBMED | **CROSSREF**

12. Park KS. Factors affecting awareness of myocardial infarction symptoms among the general public in Korea. *Epidemiol Health* 2020;42:e2020032.
PUBMED | **CROSSREF**

13. Abdo Ahmed AA, Mohammed Al-Shami A, Jamshed S, Fata Nahas AR, Mohamed Ibrahim MI. Public awareness of and action towards heart attack symptoms: an exploratory study. *Int J Environ Res Public Health* 2020;17:8982.
PUBMED | **CROSSREF**

14. Quah JL, Yap S, Cheah SO, et al. Knowledge of signs and symptoms of heart attack and stroke among Singapore residents. *BioMed Res Int* 2014;2014:572425.
PUBMED | **CROSSREF**

15. Yonemoto N, Kada A, Yokoyama H, Nonogi H. Public awareness of the need to call emergency medical services following the onset of acute myocardial infarction and associated factors in Japan. *J Int Med Res* 2018;46:1747-55.
PUBMED | **CROSSREF**

16. Sharma A, Vidusha K, Suresh H, et al. Global awareness of myocardial infarction symptoms in general population: a systematic review and meta-analysis. *Korean Circ J* 2021;51:983-96.
PUBMED | **CROSSREF**

17. Park YH, Kang GH, Song BG, et al. Factors related to prehospital time delay in acute ST-segment elevation myocardial infarction. *J Korean Med Sci* 2012;27:864-9.
PUBMED | **CROSSREF**

18. Dombrowski SU, Mackintosh JE, Sniehotta FF, et al. The impact of the UK 'Act FAST' stroke awareness campaign: content analysis of patients, witness and primary care clinicians' perceptions. *BMC Public Health* 2013;13:915.
PUBMED | **CROSSREF**

19. Mathews R, Peterson ED, Li S, et al. Use of emergency medical service transport among patients with ST-segment-elevation myocardial infarction: findings from the National Cardiovascular Data Registry Acute Coronary Treatment Intervention Outcomes Network Registry-Get With The Guidelines. *Circulation* 2011;124:154-63.
PUBMED | **CROSSREF**

20. Lee SH, Kim HK, Jeong MH, et al. Pre-hospital delay and emergency medical services in acute myocardial infarction. *Korean J Intern Med* 2020;35:119-32.
PUBMED | **CROSSREF**

21. Ho AF, Fook-Chong S, Pek PP, Ng YY, Wong AS, Ong ME. Prehospital presentation of patients with ST-segment elevation myocardial infarction in Singapore. *Int J Cardiol* 2013;168:4273-6.
PUBMED | **CROSSREF**

22. Tan LL, Wong HB, Poh CL, et al. Utilisation of emergency medical service among Singapore patients presenting with ST-segment elevation myocardial infarction: prevalence and impact on ischaemic time. *Intern Med J* 2011;41:809-14.
PUBMED | **CROSSREF**

23. Liu Z, Lim MJ, Pek PP, et al. Improved door-to-balloon time for primary percutaneous coronary intervention for patients conveyed via emergency ambulance service. *Ann Acad Med Singapore* 2021;50:671-8.
PUBMED | **CROSSREF**

24. Mohd Hassan NZ, Bahari MS, Aminuddin F, et al. Data envelopment analysis for ambulance services of different service providers in urban and rural areas in Ministry of Health Malaysia. *Front Public Health* 2023;10:959812.
PUBMED | **CROSSREF**

25. Ong ME, Cho J, Ma MH, et al. Comparison of emergency medical services systems in the pan-Asian resuscitation outcomes study countries: report from a literature review and survey. *Emerg Med Australas* 2013;25:55-63.
PUBMED | **CROSSREF**

26. Shin SD, Ong ME, Tanaka H, et al. Comparison of emergency medical services systems across Pan-Asian countries: a web-based survey. *Prehosp Emerg Care* 2012;16:477-96.
PUBMED | **CROSSREF**

27. O'Gara PT, Kushner FG, Ascheim DD, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2013;61:e78-140.
PUBMED | **CROSSREF**

28. Ong ME, Wong AS, Seet CM, et al. Nationwide improvement of door-to-balloon times in patients with acute ST-segment elevation myocardial infarction requiring primary percutaneous coronary intervention with out-of-hospital 12-lead ECG recording and transmission. *Ann Emerg Med* 2013;61:339-47.
PUBMED | **CROSSREF**

29. Ministry of Health Malaysia; National Heart Association of Malaysia; Academy of Medicine of Malaysia. *Clinical Practice Guideline: Management of Acute ST-Elevation Myocardial Infarction (STEMI), 2019.* 4th ed. Kuala Lumpur: National Heart Association of Malaysia; 2019 [cited 2023 April 3]. Available from: https://www.malaysianheart.org/?p=cpg&a=1347.

30. Matsuzawa Y, Kosuge M, Fukui K, Suzuki H, Kimura K. Present and future status of cardiovascular emergency care system in urban areas of Japan - importance of prehospital 12-lead electrocardiogram. *Circ J* 2022;86:591-9.
PUBMED | **CROSSREF**

31. Cha JJ, Hong SJ. A simple protocol to save time delay for patients with ST-elevation myocardial infarction by using pre-hospital electrocardiogram transmission program. *Korean Circ J* 2020;50:720-2.
PUBMED | **CROSSREF**

32. Mori H, Maeda A, Akashi Y, et al. The impact of pre-hospital 12-lead electrocardiogram and first contact by cardiologist in patients with ST-elevation myocardial infarction in Kanagawa, Japan. *J Cardiol* 2021;78:183-92.
PUBMED | **CROSSREF**

33. Takeuchi I, Fujita H, Yanagisawa T, et al. Impact of doctor car with mobile cloud ECG in reducing door-to-balloon time of Japanese ST-elevation myocardial infarction patients. *Int Heart J* 2015;56:170-3.
PUBMED | **CROSSREF**

34. Rahme RJ, Fishman AJ, Hunt Batjer H, Bendok BR. The future is now: smartphones to join scalpels and stethoscopes? *Neurosurgery* 2012;70:N19-20.
PUBMED | **CROSSREF**

35. Magimel-Pelonnier E, Marjanovic N, Couvreur R, Drugeon B, Mimoz O, Guenezan J. Photography tele-transmission by regular ambulance staff for the management of mild traumatic injury: the NiCEPHORE randomised-controlled trial. *Scand J Trauma Resusc Emerg Med* 2022;30:53.
PUBMED | **CROSSREF**

36. Takano T, Ida T, Tanaka K, Obayashi K, Kimura E. Prehospital care (CCU network) of acute myocardial infarction and treatment of cardiogenic shock by intra-aortic balloon pumping. *Jpn Circ J* 1981;45:623-35.
PUBMED | **CROSSREF**

37. Yusof TN, Liu KT, Kasim S. Impact of a regional STEMI network on patient outcomes in Malaysia. *Int J Cardiol* 2019;297:16.
CROSSREF

38. Alexander T, Victor SM, Mullasari AS, et al. Protocol for a prospective, controlled study of assertive and timely reperfusion for patients with ST-segment elevation myocardial infarction in Tamil Nadu: the TN-STEMI programme. *BMJ Open* 2013;3:e003850.
PUBMED | **CROSSREF**

39. Zhang Y, Yu B, Han Y, et al. Protocol of the China ST-Segment Elevation Myocardial Infarction (STEMI) Care Project (CSCAP): a 10-year project to improve quality of care by building up a regional STEMI care network. *BMJ Open* 2019;9:e026362.
PUBMED | **CROSSREF**

40. Wang JM, Kim BO, Bae JW, Oh DJ. Implementation of national health policy for the prevention and control of cardiovascular disease in South Korea: regional-local cardio-cerebrovascular center and nationwide registry. *Korean Circ J* 2021;51:383-98.
PUBMED | **CROSSREF**

41. Takeda M, Oami T, Hayashi Y, et al. Prehospital diagnostic algorithm for acute coronary syndrome using machine learning: a prospective observational study. *Sci Rep* 2022;12:14593.
PUBMED | **CROSSREF**

42. Choi A, Kim MJ, Sung JM, et al. Development of prediction models for acute myocardial infarction at prehospital stage with machine learning based on a nationwide database. *J Cardiovasc Dev Dis* 2022;9:430.
PUBMED | **CROSSREF**

43. Chen KW, Wang YC, Liu MH, et al. Artificial intelligence-assisted remote detection of ST-elevation myocardial infarction using a mini-12-lead electrocardiogram device in prehospital ambulance care. *Front Cardiovasc Med* 2022;9:1001982.
PUBMED | **CROSSREF**

44. Jacobsen L, Grenne B, Olsen RB, Jortveit J. Feasibility of prehospital identification of non-ST-elevation myocardial infarction by ECG, troponin and echocardiography. *Emerg Med J* 2022;39:679-84.
PUBMED | **CROSSREF**

45. Ministry of Health Malaysia; National Heart Association of Malaysia; Academy of Medicine of Malaysia. *Clinical Practice Guideline: Management of Non-ST Elevation Myocardial Infarction (NSTE-ACS), 2021*. 3rd ed. Kuala Lumpur: National Heart Association of Malaysia; 2021 [cited 2023 April 3]. Available from: https://www.malaysianheart.org/?p=cpg&a=1687.

46. Kimura K, Kimura T, Ishihara M, et al. JCS 2018 guideline on diagnosis and treatment of acute coronary syndrome. *Circ J* 2019;83:1085-196.
    PUBMED | **CROSSREF**

47. Kim HK, Ahn Y, Chang K, et al. 2020 Korean Society of Myocardial Infarction expert consensus document on pharmacotherapy for acute myocardial infarction. *Korean Circ J* 2020;50:845-66.
    PUBMED | **CROSSREF**

48. Chang K, Ahn Y, Lim S, et al. 2021 Korean Society of Myocardial Infarction expert consensus document on revascularization for acute myocardial infarction. *Korean Circ J* 2021;51:289-307.
    PUBMED | **CROSSREF**

49. Daghash H, Lim Abdullah K, Ismail MD. The effect of acute coronary syndrome care pathways on in-hospital patients: a systematic review. *J Eval Clin Pract* 2020;26:1280-91.
    PUBMED | **CROSSREF**

50. Nakamura I, Hori S, Suzuki M, et al. Critical pathway improves arrival-in-cath-lab interval for patients with acute myocardial infarction in the emergency department. *Jpn Circ J* 2001;65:849-52.
    PUBMED | **CROSSREF**

51. Cheah J. Clinical pathways--an evaluation of its impact on the quality of care in an acute care general hospital in Singapore. *Singapore Med J* 2000;41:335-46.
    PUBMED

52. Park YS, Chung SP, You JS, et al. Effectiveness of a multidisciplinary critical pathway based on a computerised physician order entry system for ST-segment elevation myocardial infarction management in the emergency department: a retrospective observational study. *BMJ Open* 2016;6:e011429.
    PUBMED | **CROSSREF**

53. Hai JJ, Wong CK, Un KC, et al. Guideline-based critical care pathway improves long-term clinical outcomes in patients with acute coronary syndrome. *Sci Rep* 2019;9:16814.
    PUBMED | **CROSSREF**

54. Ahmed T, Paracha MY, Khan B, et al. Impact of AMI standard clinical pathway on clinical outcomes in the management of acute myocardial infarction patient in a public tertiary care hospital, Karachi-Pakistan. *Ann Med Health Sci Res* 2021;11:80-7.

55. Rathod KS, Comer K, Casey-Gillman O, et al. Early hospital discharge following PCI for patients with STEMI. *J Am Coll Cardiol* 2021;78:2550-60.
    PUBMED | **CROSSREF**

56. Arakawa T, Kumasaka L, Nakanishi M, et al. Regional clinical alliance path and cardiac rehabilitation after hospital discharge for acute myocardial infarction patients in Japan - a nationwide survey. *Circ J* 2016;80:1750-5.
    PUBMED | **CROSSREF**

57. Dalal JJ, Krittayaphong R, Nicholls SJ, Soomro K, Yeo KK. Consensus recommendations of the Asia Pacific Cardiometabolic Consortium on secondary prevention strategies in myocardial infarction: recommendations on pharmacotherapy, lifestyle modification and cardiac rehabilitation. *J Asian Pac Soc Cardiol* 2023;2:e01.
    CROSSREF

58. Tern PJW, Ho AKH, Sultana R, et al. Comparative overview of ST-elevation myocardial infarction epidemiology, demographics, management, and outcomes in five Asia-Pacific countries: a meta-analysis. *Eur Heart J Qual Care Clin Outcomes* 2021;7:6-17.
    PUBMED | **CROSSREF**

59. Kim Y, Ahn Y, Cho MC, Kim CJ, Kim YJ, Jeong MH. Current status of acute myocardial infarction in Korea. *Korean J Intern Med* 2019;34:1-10.
    PUBMED | **CROSSREF**

60. Nakao K, Yasuda S, Nishimura K, et al. Prescription Rates of guideline-directed medications are associated with in-hospital mortality among Japanese patients with acute myocardial infarction: a report from JROAD - DPC study. *J Am Heart Assoc* 2019;8:e009692.
    PUBMED | **CROSSREF**

61. Singapore Myocardial Infarction Registry. *Trends in Acute Myocardial Infarction in Singapore 2007–2013*. Singapore: National Registry of Diseases Office; 2013.

62. Kim JH, Chae SC, Oh DJ, et al. Multicenter cohort study of acute myocardial infarction in Korea - interim analysis of the Korea Acute Myocardial Infarction Registry-National Institutes of Health Registry. *Circ J* 2016;80:1427-36.
    PUBMED | **CROSSREF**

63. Daida H, Miyauchi K, Ogawa H, et al. Management and two-year long-term clinical outcome of acute coronary syndrome in Japan: prevention of atherothrombotic incidents following ischemic coronary attack (PACIFIC) registry. *Circ J* 2013;77:934-43.
PUBMED | **CROSSREF**

64. Venkatason P, Zubairi YZ, Hafidz I, Wan WA, Zuhdi AS. Trends in evidence-based treatment and mortality for ST elevation myocardial infarction in Malaysia from 2006 to 2013: time for real change. *Ann Saudi Med* 2016;36:184-9.
PUBMED | **CROSSREF**

65. Venkatason P, Zaharan NL, Ismail MD, Wan Ahmad WA, Mahmood Zuhdi AS. Trends and variations in the prescribing of secondary preventative cardiovascular therapies for non-ST elevation myocardial infarction (NSTEMI) in Malaysia. *Eur J Clin Pharmacol* 2018;74:953-60.
PUBMED | **CROSSREF**

66. Byeon HJ, Yang YM, Choi EJ. Optimal medical therapy for secondary prevention after an acute coronary syndrome: 18-month follow-up results at a tertiary teaching hospital in South Korea. *Ther Clin Risk Manag* 2016;12:167-75.
PUBMED | **CROSSREF**

67. Tam LM, Fonarow GC, Bhatt DL, et al. Achievement of guideline-concordant care and in-hospital outcomes in patients with coronary artery disease in teaching and nonteaching hospitals: results from the Get With The Guidelines-Coronary Artery Disease program. *Circ Cardiovasc Qual Outcomes* 2013;6:58-65.
PUBMED | **CROSSREF**

68. Kim RB, Hwang JY, Park HW, et al. Contemporary status of acute myocardial infarction in Korean patients: Korean Registry of Acute Myocardial Infarction for Regional Cardiocerebrovascular Centers. *J Clin Med* 2021;10:498.
PUBMED | **CROSSREF**

69. Honda S, Nishihira K, Kojima S, et al. Rationale, design, and baseline characteristics of the prospective Japan Acute Myocardial Infarction Registry (JAMIR). *Cardiovasc Drugs Ther* 2019;33:97-103.
PUBMED | **CROSSREF**

70. Miyachi H, Yamamoto T, Takayama M, et al. 10-Year temporal trends of in-hospital mortality and emergency percutaneous coronary intervention for acute myocardial infarction. *JACC Asia* 2022;2:677-88.
PUBMED | **CROSSREF**

71. Chin SP, Jeyaindran S, Azhari R, et al. Acute coronary syndrome (ACS) registry - leading the charge for National Cardiovascular Disease (NCVD) Database. *Med J Malaysia* 2008;63 Suppl C:29-36.
PUBMED

72. Srimahachota S, Kanjanavanit R, Boonyaratavej S, et al. Demographic, management practices and in-hospital outcomes of Thai Acute Coronary Syndrome Registry (TACSR): the difference from the Western world. *J Med Assoc Thai* 2007;90 Suppl 1:1-11.
PUBMED

73. Bi Y, Gao R, Patel A, et al. Evidence-based medication use among Chinese patients with acute coronary syndromes at the time of hospital discharge and 1 year after hospitalization: results from the Clinical Pathways for Acute Coronary Syndromes in China (CPACS) study. *Am Heart J* 2009;157:509-516.e1.
PUBMED | **CROSSREF**

74. Liu KT, Lee SWH, Selvaraj SG, et al. An update on acute coronary syndrome and myocardial infarction registries among member countries of the Asian Pacific Society of Cardiology. *J Asian Pac Soc Cardiol* 2022;1:e27.
CROSSREF

75. Kim HK, Jeong MH, Lee SH, et al. The scientific achievements of the decades in Korean Acute Myocardial Infarction Registry. *Korean J Intern Med* 2014;29:703-12.
PUBMED | **CROSSREF**

76. Jollis JG, Al-Khalidi HR, Roettig ML, et al. Impact of regionalization of ST-segment-elevation myocardial infarction care on treatment times and outcomes for emergency medical services-transported patients presenting to hospitals with percutaneous coronary intervention: mission: lifeline accelerator-2. *Circulation* 2018;137:376-87.
PUBMED | **CROSSREF**