Original Article

The outcome of primary percutaneous coronary intervention in patients with stent thrombosis

Mukesh Kumar*, Ghulam Shabbir Shar, Rajesh Kumar, Abdul Hakeem Shaikh, Haroon Ishaque, Naveedullah Khan, Fawad Farooq, Tahir Saghir, Tariq Ashraf, Musa Karim

National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan

Abstract

Background: Primary percutaneous coronary intervention (PCI) is a recommended management strategy for patients with de novo ST-segment elevation myocardial infarction (STEMI). Still, the efficacy of primary PCI in-stent thrombosis (ST) induced STEMI is unclear. The aim was to assess the clinical characteristics and the in-hospital outcomes of patients undergoing primary PCI for STEMI caused by acute, sub-acute, or late ST.

Methods: A sample of hundred consecutive patients who presented with STEMI due to ST were included in this study. The angiographic evidence of a flow-limiting thrombus or total vessel occlusion (thrombolysis in myocardial infarction (TIMI) flow grade 0 to II) at the site of the previous stent implant was taken as ST. Primary PCI was performed, and all enrolled patients and in-hospital mortality were observed.

Results: Male patients were 69, and the mean age was 58.9 ± 7.78 years. ST was categorized as acute in 40 patients, sub-acute in 53, and late in the remaining seven patients. Killip class III/IV was observed in 45 patients. Dissection was observed in 25, under deployment in 74, and/or malposition in 24 patients. Thrombus aspiration was performed in 97, plain old balloon angioplasty in 76, and stenting in 22 patients. Final TIMI III flow was achieved in 32 patients. During a mean hospital stay of 4.93 ± 2.46 days, the mortality rate was 27%.

Conclusion: In-hospital mortality after primary PCI was observed in more than 1/4th of the patients with STEMI due to ST undergoing primary PCI.

© 2022 Published by Elsevier, a division of RELX India, Pvt. Ltd on behalf of Cardiological Society of India. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Emergency percutaneous coronary revascularization, with or without stenting, is the preferred and recommended mode of management for patients with ST-segment elevation myocardial infarction (STEMI). Worldwide adoption of primary percutaneous coronary intervention (PCI) has significantly improved the survival and outcomes of these patients. Owing to the advancements in the mechanical and pharmacological aspects of the percutaneous interventions, outcomes have been and enhanced for most STEMI patients. Still, stent thrombosis (ST) remained a relatively rare but dreaded complication of PCI. The introduction of drug-eluting stents (DES) was undoubtedly a milestone however, ST was one of the main safety concerns with 1st generation DES this has been addressed in the 2nd generation DES with biodegradable or biocompatible durable polyurethane and stent platform with thinner strut.

The pathophysiological mechanism behind the development of ST is not very clear, and multiple triggers have been postulated; lesion morphology and characteristics, adherence with dual anti-platelet therapy (DAPT), presence of diabetes, and stent type and design are the commonly reported factors. The histopathological examinations of thrombus samples revealed heterogeneity in its composition, erythrocytes, fibrin/fibrinogen fragments, and platelet-rich thrombus were widely observed in histopathological

* Corresponding author.
E-mail address: mukesh_nicvd@yahoo.com (M. Kumar).

https://doi.org/10.1016/j.ihj.2022.11.003
0019-4832/© 2022 Published by Elsevier, a division of RELX India, Pvt. Ltd on behalf of Cardiological Society of India. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Ticagrelor (90 mg BD) in 50 patients, and the remaining were prescribed with Aspirin (100 mg) and the administration of the recommended dose of unfractious operator's discretion. However, pre-, peri-, and post-procedure thrombus aspiration (export), plain (performed by on call interventional cardiology team. During most of the patients, thrombogenicity of uncovered stent struts, disturbance of blood flow, and polymer materials can be possible underlying factors for patients without underlying plaque pathology. 3 The pathophysiological, histopathological, and clinical distinction of ST due to ST guidelines are not very clear about the optimal management strategy for this high-risk group of patients. 4 Thrombus aspiration, balloon angioplasty and stenting in some cases have been adopted for the management of ST due to ST. 8,14

Therefore, in this study, we aimed to assess the clinical and procedural characteristics and the in-hospital outcomes of patients undergoing primary PCI for STEMI caused by acute, sub-acute, or late ST.

2. Methods

A sample of hundred consecutive patients who presented with STEMI due to ST at tertiary care hospital were included in this study. This study was conducted from April 2021 to March 2022 after approval from the institution’s ethical review committee (ERC-60/2020). Study inclusion criteria were; both male and female adult patients (≥18 years), diagnosed with STEMI due to acute, sub-acute, or late stent thrombosis and undergoing primary PCI. Patients who refused to participate or did not undergo primary PCI for any reason were excluded from the study.

The angiographic evidence of a presence of flow-limiting thrombus or total vessel occlusion (thrombolysis in myocardial infarction (TIMI) flow grade 0 to II) at the site of the previous stent implant was taken as ST. ST was further categorized as acute, sub-acute, or late ST based on the time of onset after the stent deployment i.e. within 24 h, up to 30 days, or beyond 30 days, respectively. 1 The drug eluting stent (resolute integrity, paclitaxel or zotarolimus) are implanted in most patients. Diagnosis of STEMI was made based on the history of chest pain at presentation (>20 min) and electrocardiographic (ECG) changes. All patients diagnosed with STEMI presented within 12 h of symptoms were immediately taken to the catheterization laboratory. ST was confirmed based on angiography, and primary PCI procedures were performed by on call interventional cardiology team. During most (>90%) of the procedures, infusion of Glycoprotein IIb/IIIa (GP IIb/IIIa) inhibitors as administered. Thrombus aspiration (export), plain balloon angioplasty (POBA), and/or stenting were performed at the operator’s discretion. However, pre-, peri-, and post-procedure management of all the patients was according to standard care with the administration of the recommended dose of unfractionated heparin, DAPT, and/or glycoprotein inhibitors (IIb/IIIa). Post-procedure all patients were prescribed with Aspirin (100 mg) and Ticagrelor (90 mg BD) in 50 patients, and the remaining were prescribed with Clopidogrel. All patients were prescribed Statin (40 mg single dose of Atorvastatin).

Enrolled patients were observed for in-hospital mortality. Patients’ clinical and procedure-related details were collected on a structured proforma. Details of previously deployed stents were obtained from patients’ files and hospital records, this included type of stent and length and diameter of the stent. Mechanisms of ST, such as dissection, under deployment, or malposition, were reported by the primary operator on conventional angiogram. Patients’ adherence with DAPT (aspirin, clopidogrel, or ticagrelor) and stents was taken. Analysis of data was carried out with the help of IBM SPSS version 21. Variables of continuous nature were summarized as either mean ± standard deviation (SD) or median interquartile range (IQR) and compared by in-hospital mortality status with the help of an appropriate independent sample t-test or Mann–Whitney U test. Similarly, variables of categorical nature were summarized as frequency (%) and compared by in-hospital mortality status with the help of the Chi-square test/Likelihood ratio/Fisher’s Exact test with a 5% level of significance.

3. Results

A total of 100 patients were included in this study, out of which male patients were 69 and mean age was 58.9 ± 7.78 years. ST was categorized as acute in 40 patients, sub-acute in 53, and late in the remaining 7 patients. Killip class III/IV was observed in 45 patients. Dissection was observed in 25, under deployment in 74, and/or malposition in 24 patients. Thrombus aspiration was performed in 97, plain old balloon angioplasty in 76, and stenting in 22 patients. The intra-aortic balloon pump (IABP) was placed in 21 (21%) patients. Final TIMI III flow was achieved in only 32 patients. During mean hospital stay of 4.9 ± 2.46 days, mortality rate was 27% (27). Mortality was due to arrhythmias in 15 patients, heart/pump failure in 10 patients, mechanical complications in one patient, and one patient died due to multi-organ failure. Distribution of and comparison of clinical and procedure-related details by survival status after primary percutaneous coronary intervention for stent thrombosis-induced ST-segment elevation myocardial infarction are presented in Table 1.

4. Discussion

The primary PCI is a recommended management strategy for patients with de novo STEMI, but the efficacy of primary PCI in ST-induced STEMI is unclear. Minimal data are available in this regard, especially from the developing world. Therefore, this study evaluated the in-hospital mortality rate and clinical profile of patients undergoing primary PCI for STEMI due to ST. The in-hospital mortality rate after primary PCI was observed to be 27%. The clinical outlook of the ST-induced STEMI was predominantly male, Killip III/IV at presentation.

Mostly hypertensive, nearly 2/3rd diabetics, nearly half smokers, mostly with high thrombus burden (IV/V), multi-vessel disease, and mostly left main or anterior territory involvement.

Although, local evidence on the incidence of ST after primary PCI is very limited. Some of the recent studies from our population reported the incidence of acute or sub-acute ST as 4.9% and 5.8%. It is lower which is much lower than that reported for our population. In this study 93% of the cases were found to have acute or sub-acute stent thrombosis, similar to our observations Singh K et al reported 79% of ST cases within first 24 h of the stent deployment.

Contrary to our findings, very late ST was observed in 85% of the patients in a study of 128 consecutive patients with ST by
Table 1  
Distribution of and comparison of patients' clinical and procedure-related details by survival status after primary percutaneous coronary intervention for stent thrombosis induced ST-segment elevation myocardial infarction.

| Characteristics | Total (N) | In-hospital Outcome | P-value |
|-----------------|----------|---------------------|---------|
|                 | 100      | 73 (73%)            | 27 (27%)|
| **Gender**      |          |                     |         |
| Male            | 69% (69) | 68.5% (50)          | 70.4% (19) | 0.857a |
| Female          | 31% (31) | 31.5% (23)          | 29.6% (8) |
| **Age (years)** |          | 58.9 ± 7.78         | 58.71 ± 6.58 | 59.41 ± 10.5 | 0.750b |
| **Chest pain to ER time (h)** | 2 [1.65–3] | 2 [1.3–3] | 3 [2–5] | 0.107c |
| **ER To Lab time (minutes)** | 60 [30–72.5] | 60 [30–68] | 60 [30–120] | 0.614c |
| **Killip Class** |          |                     |         |
| I               | 14% (14) | 12.3% (9)           | 18.5% (5) | <0.001a |
| II              | 41% (41) | 53.4% (39)         | 7.4% (2) |
| III             | 32% (32) | 24.7% (18)         | 51.9% (14) |
| IV              | 13% (13) | 9.6% (7)           | 22.2% (6) |
| **Co-morbid conditions** |          |                     |         |
| Hypertension    | 80% (80) | 83.6% (61)        | 70.4% (19) | 0.143a |
| Diabetes Mellitus | 72% (72) | 69.9% (51)       | 77.8% (21) | 0.434a |
| Smoking         | 47% (47) | 47.9% (35)       | 44.4% (12) | 0.755a |
| Family history of CAD | 5% (5) | 4.1% (3)       | 7.4% (2) | 0.610d |
| **Stent Thrombosis** |          |                     |         |
| Acute           | 40% (40) | 38.4% (28)        | 44.4% (12) | 0.099e |
| Sub-acute       | 53% (53) | 52.1% (38)       | 55.6% (15) |
| Late            | 7% (7)   | 9.6% (7)          | 0% (0) |
| **Thrombus grade** |          |                     |         |
| I               | 1% (1)   | 0% (0)            | 3.7% (1) | 0.396e |
| II              | 3% (3)   | 2.7% (2)          | 3.7% (1) |
| III             | 17% (17) | 16.4% (12)       | 18.5% (5) |
| IV              | 35% (35) | 32.9% (24)       | 40.7% (11) |
| V               | 44% (44) | 47.9% (35)       | 33.3% (9) |
| **Stent type**  |          |                     |         |
| Drug-eluting stent | 99% (99) | 98.6% (72) | 100% (27) | >0.999d |
| Bare metal stents | 1% (1) | 1.4% (1)       | 0% (0) |
| **Total length of stent** | 27.64 ± 7.12 | 27.96 ± 7.3 | 26.78 ± 6.66 | 0.464b |
| **Average diameter of stent** | 3.17 ± 0.32 | 3.16 ± 0.3 | 3.19 ± 0.36 | 0.753b |
| **Causes of stent thrombosis** |          |                     |         |
| Dissection      | 25% (25) | 27.4% (20)       | 18.5% (5) | 0.363a |
| Under deployed  | 74% (74) | 74% (54)         | 74.1% (20) | 0.992a |
| Malaposition    | 24% (24) | 24.7% (18)       | 22.2% (6) | 0.800a |
| **Post dilation** |          |                     |         |
| 87% (87)        | 89% (65) | 81.5% (22)       | 0.329a |
| **Medications Adherence** |          |                     |         |
| Aspirin         | 100% (100) | 100% (73) | 100% (27) | – |
| Clopidogrel     | 96% (96) | 94.5% (69)       | 100% (27) | 0.572a |
| Statin          | 99% (99) | 98.6% (72)       | 100% (27) | >0.999a |
| **Number of involved vessels** |          |                     |         |
| Single vessel disease | 9% (9) | 6.8% (5)       | 14.8% (4) | 0.004e |
| Two vessel disease | 49% (49) | 58.9% (43) | 22.2% (6) |
| Three vessel disease | 42% (42) | 34.2% (25) | 63% (17) |
| **Culprit Vessel** |          |                     |         |
| Left main       | 4% (4)   | 0% (0)           | 14.8% (4) | 0.003e |
| Left anterior descending artery | 54% (54) | 52.1% (38) | 59.3% (16) |
| Right coronary artery | 25% (25) | 30.1% (22) | 11.1% (3) |
| Left circumflex artery | 17% (17) | 17.8% (13) | 14.8% (4) |
| **Management**  |          |                     |         |
| Export          | 97% (97) | 95.9% (70)        | 100% (27) | 0.561a |
| Balloon         | 76% (76) | 72.6% (53)       | 85.2% (23) | 0.191a |
| Stenting        | 22% (22) | 26% (19)         | 11.1% (3) | 0.110a |
| *Length of Stent* | 13.95 ± 3.23 | 14.21 ± 3.41 | 12.33 ± 0.58 | 0.362b |
| *Diameter of Stent* | 3.06 ± 0.28 | 3.04 ± 0.28 | 3.17 ± 0.29 | 0.474b |
| **TIMI (thrombolysis in myocardial infarction) flow grade** |          |                     |         |
| 0               | 4% (4)   | 1.4% (1)         | 11.1% (3) | <0.001e |
| I               | 15% (15) | 4.1% (3)         | 44.4% (12) |
| II              | 49% (49) | 50.7% (37)       | 44.4% (12) |
| III             | 32% (32) | 43.8% (32)       | 0% (0) |
| **Length of stay (days)** | 4.93 ± 2.46 | 5.71 ± 2.31 | 2.81 ± 1.39 | <0.001b |

*a = Chi-square test, b = independent sample t-test, c = Mann–Whitney U test, d = Fisher's Exact test, e = Likelihood ratio test.

*Based on patients in whom new stents were deployed.

CAD = coronary artery diseases, ER = emergency room, TIMI = thrombolysis in myocardial infarction.
Konstantinou K et al.22 This study further reported that manual thrombus aspiration is not associated with improved reperfusion or long-term outcomes in contemporary PCI setting for ST patients.22 Similarly, Noaman S et al.23 also reported very late ST in 64% of the cases. Compared to de novo STEMI, patients with STEMI due to ST were found to have a higher prevalence of dyslipidemia, hypertension, and diabetes mellitus, and outcomes after primary PCI in patients with STEMI due to ST were comparable to the outcomes of de novo STEMI.24 However, in-hospital mortality in our study was observed to be much higher than the conventionally reported mortality rate after primary PCI. One of the possible reasons was the higher distribution of acute or sub-acute ST as a recent systematic review and meta-analysis reported significantly worst short- and long-term clinical outcomes among patients with early ST compared to late or very late ST.25 Supporting these findings He C et al.26 also reported no significant differences in outcomes after late stent thrombosis compared to de novo lesion. However, contrary to the observations of these studies, Ergelen M et al.27 reported significantly higher in-hospital cardiovascular mortality among ST induced STEMI patients (10.2% vs. 5.3%; p = 0.02) as compared to de novo lesion, hence, less effectiveness of primary PCI for STEMI due to ST was concluded by this study.27 A Japanese registry based study by Ohno Y et al.28 had similar observations regarding increased risk of adverse outcomes and complications and recurrent ST among acute coronary syndrome (ACS) patients presented with ST.27 Similarly, Kim MC et al.29 reported death or recurrent ST in nearly 1/4th of the patients with ST during first year follow-up after ST event. Increased risk of adverse outcomes and failure to achieve the optimal TIMI flow after primary PCI in patients with ST can be attributed to several factors such as high burden of co-morbidities, older age, hemodynamically unstable presentation (high Killip class), multi-vessel diseases, and high thrombus burden.

The present study has certain limitations, starting with inherent observational design and single-center coverage. Lack of follow-up for assessing short- or long-term outcomes is another main limitation. The intracoronary imaging is current gold standard, but our center is a high-burden center which provide free of cost services to all types of cardiovascular disease patients, hence, intracoronary imaging was not feasible in all patients and the mechanisms of ST was evaluated based on conventional angiogram which might be a less sensitive modality of the assessment. Finally, multivariable analysis for assessing associated factors with in-hospital mortality was not feasible due to the small sample size. Further longitudinal and randomized studies are required to access the primary efficacy of PCI in patients with STEMI due to ST.

5. Conclusion

In conclusion, for patients presenting to the hospital with STEMI due to ST and treated with primary PCI, the in hospital mortality was observed in more than 1/4th of the patients. Dissection, under deployment, and/or malposition were the commonly observed mechanism behind ST. Increased risk of adverse outcomes can be attributed to the high co-morbidities, older age, hemodynamically unstable presentation (high Killip class), multi-vessel diseases, and high thrombus burden. Further longitudinal and randomized studies are required to access the efficacy of primary PCI in patients with STEMI due to ST.

Declarations

Competing interest

All authors have no conflict of interest to disclose.

Funding

None to declare.

References

1. Levine GN, Bates ER, Blankenship JC, et al. ACC/AHA/SCAI focused update on primary percutaneous coronary intervention for patients with ST-elevation myocardial infarction: an update of the 2011 ACCF/AHA/SCAI guideline for percutaneous coronary intervention and the 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction. J Am Coll Cardiol. 2015;65(10):1235–1250, 2016.
2. Yang YX, Liu Y, Li XW, et al. Clinical outcomes after percutaneous coronary intervention for early versus late and very late stent thrombosis: a systematic review and meta-analysis. J Thromb Thrombolysis. 2021;51(3):682–692.
3. Tada T, Byrne RA, Simunic I, et al. Risk of stent thrombosis among bare-metal stents, first-generation drug-eluting stents, and second-generation drug-eluting stents: results from a registry of 18,334 patients. JACC Cardiovasc Interv. 2013;6:1267–1274.
4. Philip P, Aggarwal S, Bunte MC, et al. Stent thrombosis with second-generation drug-eluting stents compared with bare-metal stents: network meta-analysis of primary percutaneous coronary intervention trials in ST-segment–elevation myocardial infarction. Circ Cardiovasc Interv. 2014;7(1):49–61.
5. vanWerkum JW, Heathermans AA, Zomer AC, et al. Predictors of coronary stent thrombosis: the Dutch stent thrombosis registry. J Am Coll Cardiol. 2009;53:1399–1409.
6. Kimura T, Morimoto T, Kozuma K, et al. Comparisons of baseline demographics, clinical presentation, and long-term outcome among patients with early, late, and very late stent thrombosis of sirolimus-eluting stents: observations from the registry of stent thrombosis for review and reevaluation (RESTART). Circulation. 2010;122:52–61.
7. Rieger J, Byrne RA, Joner M, et al. Histopathological evaluation of thrombus in patients presenting with stent thrombosis. A multicenter European study: a report of the prevention of late stent thrombosis by an interdisciplinary global European effort consortium. Eur Heart J. 2016;37(19):1538–1548.
8. Souteyrand G, Amabile N, Mangin L, et al. Mechanisms of stent thrombosis analysed by optical coherence tomography: insights from the national PESTO French registry. Eur Heart J. 2016;37(15):1208–1216.
9. Godschalk TC, Byrne RA, Adriaenssens T, et al. Observational study of platelet reactivity in patients presenting with ST-segment elevation myocardial infarction due to coronary stent thrombosis undergoing primary percutaneous coronary intervention: results from the European Prevention of Stent Thrombosis by an Interdisciplinary Global European Effort Registry. JACC Cardiovasc Interv. 2017;10(24):2548–2556.
10. Cutlip DE, Windecker S, Mehran R, et al. Clinical end points in coronary stent trials: a case for standardized definitions. Circulation. 2007;115:2344–2351.
11. Byrne RA, Joner M, Kastrati A. Stent thrombosis and restenosis: what have we learned and where are we going? The Andreas Grüntzig Lecture ESC 2014. Eur Heart J. 2015;36(47):3320–3331.
12. Claessen BE, Henriques JP, Jaffer FA, et al. Stent thrombosis: a clinical perspective. JACC Cardiovasc Interv. 2014;7(10):1081–1092.
13. Gori T, Polimeni A, Indolfi C, et al. Predictors of stent thrombosis and their implications for clinical practice. Nat Rev Cardiol. 2019;16(4):243–256.
14. Katsikis A, Keeble TR, Davies JR, et al. Contemporary management of stent thrombosis: predictors of mortality and the role of new-generation drug-eluting stents. Cathet Cardiovasc Interv. 2020;96(1):E8–E16.
15. Taraj S, Kumar R, Fatima M, et al. Acute and sub-acute stent thrombosis: frequency, predictors and features in patients undergoing primary percutaneous intervention at a tertiary care cardiac centre. Int J Cardiol Heart Vasc. 2019;26,100427.
16. Kumar R, Ammar A, Saghir T, et al. Incidence, predictors, and outcomes of acute and sub-acute stent thrombosis after emergency percutaneous coronary revascularization with drug-eluting stents: a prospective observational study. Glob Heart. 2022;17(1):24.
17. Nakano M, Yahagi K, Otsuka F, et al. Causes of early stent thrombosis in patients presenting with acute coronary syndrome: an ex vivo human autopsy study. J Am Coll Cardiol. 2014;63(23):2510–2520.
18. Lim S, Koh YS, Kim PJ, et al. Incidence, implications, and predictors of stent thrombosis in acute myocardial infarction. Am J Cardiol. 2016;117(10):1562–1568.
19. de la Torre-Hernández JMA, Alfonso F, Hernández F, et al. Drug-eluting stent thrombosis: results from the multicenter Spanish registry ESTROFA (Estudio Español sobre TROnbosis de stents FAmacoactivos). J Am Coll Cardiol. 2008;51(10):986–990.
20. Brodu B, Polkalé Y, Garg A, et al. Predictors of early, late, and very late stent thrombosis after primary percutaneous coronary intervention with bare-metal and drug-eluting stents for ST-segment elevation myocardial infarction. JACC Cardiovasc Interv. 2012;5(10):1043–1051.
21. Singh K, Rashid M, So DY, et al. Incidence, predictors, and clinical outcomes of early stent thrombosis in acute myocardial infarction patients treated with primary percutaneous coronary angioplasty (insights from the University of Ottawa Heart Institute STEMI registry). Cathet Cardiovasc Interv. 2018;91(5):842–848.
22. Konstantinou K, Davies JR, Alsanjari O, et al. Clinical effectiveness of thrombus aspiration during percutaneous coronary intervention for stent thrombosis in a contemporary setting. *Hellenic J Cardiol*. 2022;S1109–9666(22), 00030–00036.

23. Noaman S, O’Brien J, Andrianopoulos N, et al. Clinical outcomes following ST-elevation myocardial infarction secondary to stent thrombosis treated by percutaneous coronary intervention. *Cathet Cardiovasc Interv*. 2020;96(4):E406–E415.

24. Yang YX, Liu Y, Li XW, et al. Clinical outcomes after percutaneous coronary intervention for early versus late and very late stent thrombosis: a systematic review and meta-analysis. *J Thromb Thrombolysis*. 2021;51(3):682–692.

25. He C, Ma YL, Wang CS, et al. Long-term outcomes of primary percutaneous coronary intervention with second-generation drug-eluting stents in ST-elevation myocardial infarction patients caused by very late stent thrombosis. *Chin Med J*. 2017;130(8):329–335.

26. Ergelen M, Gorgulu S, Uyarel H, et al. The outcome of primary percutaneous coronary intervention for stent thrombosis causing ST-elevation myocardial infarction. *Am Heart J*. 2010;159(4):672–676.

27. Ohno Y, Yamaji K, Kohsaka S, et al. Incidence and in-hospital outcomes of patients presenting with stent thrombosis (from the Japanese nationwide percutaneous coronary intervention registry). *Am J Cardiol*. 2020;125(5):720–726.

28. Kim MC, Kim IS, Jeong MH, et al. Incidence of cardiac death and recurrent stent thrombosis after treatment for angiographically confirmed stent thrombosis. *J Cardiol*. 2019;74(3):267–272.