Outcomes of percutaneous coronary intervention in patients with coronary chronic total occlusions with versus without type 2 diabetes mellitus

A systematic review and meta-analysis

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Abstract

Background: Nowadays, due to advanced techniques and well-trained interventionists in catheter labs, new scientific research has shown percutaneous coronary intervention (PCI) to be a safe treatment procedure in patients with chronic total occlusion (CTO). However, no study has systematically compared PCI outcomes in CTO patients with versus without type 2 diabetes mellitus (T2DM). Therefore, through this meta-analysis we aimed to systematically solve this issue.

Methods: Between September 2016 and June 2017, the Cochrane Database of Randomized Trials, EMBASE, and MEDLINE databases were carefully searched for publications comparing PCI outcomes in CTO patients with versus without T2DM. Long-term (≥1 year) adverse clinical outcomes were considered the endpoints. Discontinuous data were analyzed by RevMan 5.3 whereby odds ratios (OR) and 95% confidence intervals (CIs) were the statistical parameters.

Results: This analysis consisted of 1 randomized trial and 6 observational studies with a total number of 4571 patients with CTO (1915 patients with T2DM and 2656 patients without T2DM). Patients’ enrollment was between the years 1998 and 2015. During this long-term follow-up (≥1 year), mortality was significantly higher in CTO patients with T2DM (OR: 1.56, 95% CI: 1.05–2.31; I² = 0%, P = .03). Major adverse cardiac events (MACEs) and repeated revascularization were also significantly higher in patients with T2DM (OR: 1.30, 95% CI: 1.06–1.58; I² = 10%; P = .01) and (OR: 1.30, 95% CI: 1.06–1.59; P = .01, I² = 36%) respectively. However, myocardial infarction was not significantly different (OR: 1.01, 95% CI: 0.61–1.67; P = .96, I² = 26%).

Conclusion: During this longer follow-up period post-PCI, mortality, MACEs and repeated revascularization in CTO patients with T2DM were significantly higher compared with similar patients without T2DM. Nevertheless, whether this hypothesis is relevant or not should be confirmed in larger trials.

Abbreviations: CAD = coronary artery diseases, CTO = chronic total occlusion, MACEs = major adverse cardiac events, PCI = percutaneous coronary intervention, T2DM = type 2 diabetes mellitus.

Keywords: chronic total occlusion, major adverse cardiac events, mortality, percutaneous coronary intervention, type 2 diabetes mellitus

1. Introduction

To begin with, we should first know the definition of chronic total occlusion (CTO). CTO is the complete blockage of a coronary artery (normally ≥ 99% stenosis) for a duration of more than 3 months and it mainly affects patients with stable coronary artery disease (CAD). Even if this condition can easily be identified through coronary angiography, it is least preferred to be treated in interventional cardiology due to increased failure rates.[1] In addition, treatment for CTO varied from 1 healthcare center to another and from region to region.[2,3]

Nowadays, due to advanced techniques and well-trained interventionists in catheter labs, new scientific research has shown percutaneous coronary intervention (PCI) to be a safe treatment strategy in patients with CTO. Safley et al.[4] further demonstrated PCI to be safe even in CTO patients with type 2 diabetes mellitus (T2DM). However, no study has systematically compared PCI outcomes in CTO patients with versus without T2DM. Therefore, through this meta-analysis we aimed to systematically solve this issue.

2. Materials and methods

2.1. Searched databases and searched strategies

The Cochrane Database of Randomized Trials, EMBASE, and MEDLINE databases were carefully searched for publications (English language) comparing long-term PCI outcomes in CTO
patients with versus without T2DM by using the searched terms listed below:

1. chronic total occlusion, percutaneous coronary intervention, diabetes mellitus;
2. chronic total occlusion, coronary angioplasty, diabetes mellitus;
3. chronic total occlusion, PCI, diabetes mellitus;
4. CTO, percutaneous coronary intervention, diabetes mellitus;
5. CTO, PCI, and DM.

Reference lists of qualified articles were also checked for suitable publications.

This search was carried out by 2 independent reviewers (QW and HL) between September 2016 to June 2017 and included articles which were published from the year 2000 to 2016.

2.2. Inclusion and exclusion criteria

Inclusion criteria were:
1. randomized trials or observational studies comparing PCI outcomes in CTO patients with versus without T2DM;
2. studies reporting long-term (≥1 year) adverse outcomes as their clinical endpoints;
3. Exclusion criteria were:
4. any type of study except randomized trials or observational studies;
5. studies that did not include patients with CTO;
6. studies that did not compare adverse outcomes between T2DM and non-T2DM;
7. studies reporting short-term adverse outcomes (<1 year);
8. studies that were duplicated.

2.3. Types of participants

In this analysis, the participants were CTO patients with and without T2DM.

2.4. Endpoints and follow-ups

The endpoints were summarized in Table 1.

Endpoints included:
1. all-cause mortality;
2. myocardial infarction (MI);
3. major adverse cardiac events (MACEs) [which consisted of death, MI, and revascularization/stroke];
4. repeated revascularization (including target vessel revascularization and target lesion revascularization).

A longer follow-up period (≥1 year) was considered relevant in this analysis.

2.5. Data extraction

The same 2 reviewers who were mentioned above were involved in the data extraction process. Important information and data reporting the clinical outcomes, length of follow-up periods, type of study, periods of patients’ enrollment, total number of CTO patients with and without T2DM, the baseline features, and data reporting the total number of events that were observed in the experimental and control groups were carefully extracted and cross-checked. Any disagreement that occurred during this data extraction process was discussed and resolved by another reviewer (JD). The bias risk across trials (except observational studies) was assessed by the Cochrane Collaboration.[5]

In this analysis, PRISMA was used as the reporting guideline.[6]

2.6. Statistical analysis

Type of data to be analyzed: discontinuous.

Analytical software that was used: RevMan 5.3.

Analytical parameters: odds ratios (OR) with 95% confidence intervals (CIs).

Hypothesis testing: P value ≤ 0.05.

Heterogeneity assessment: [5] Cochrane Q statistic test and the I² statistic test.

Significance of Cochrane Q test: P value of less or equal to .05 to be considered statistically significant. Any probability above .05 will not be significant statistically.

Significance of I² statistic test: to measure inconsistency across the studies. An increasing I² value signified an increased heterogeneity whereas a lower value indicated a low level of heterogeneity.

Sensitivity analysis: each study was excluded one by one and a new analysis was carried out each time and the main results that were obtained were compared for any significant difference.

Publication bias: visual assessment of funnel plot which was obtained.

Ethical approval: not applicable for meta-analysis.

Patients’ consents: not applicable for meta-analysis.

3. Results

3.1. Searched (databases) outcomes

One hundred twelve publications were obtained. After a careful assessment by the same 2 reviewers, 78 articles were eliminated. Thirty-four full-text articles were assessed for eligibility. Further exclusions were due to the following reasons:

1. case report (2)
2. studies not including patients without T2DM (control group) (8)
3. duplicates (17)

Finally, only 7 studies (1 randomized trial[7] and 6 observational studies)[8–13] were included in this analysis as shown in Fig. 1.

3.2. Main features of the studies which were included

The main features of the studies have been listed in Table 2. This analysis consisted of 1 randomized trial and 6 observational studies with a total number of 4571 patients with CTO (1915

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**Table 1**

| Studies | Reported outcomes | Follow-up periods |
|---------|-------------------|------------------|
| Claessen 2011 | MACEs, death, MI, TVR | 5 y |
| Felice 2006 | Death, MI, revascularization | 25±15 mo |
| Liu 2013 | MACEs, death, TLR, MI | 36±12 mo |
| Rha 2015 | Death, MI, MACEs, TLR, TVR | 12 mo |
| Ruiz 2015 | Death, MI, TVR, ST, stroke | 12 mo |
| Sohrabi 2011 | Death, MI, revascularization | 12 mo |
| Parachini 2016 | Death, MACEs, MI, stroke | — |

MACEs = major adverse cardiac events, MI = myocardial infarction, ST = stent thrombosis, TLR = target lesion revascularization, TVR = target vessel revascularization.
patients with T2DM and 2,656 patients without T2DM). Period of patients’ enrollment was between the years 1998 and 2015 as shown in Table 2. A bias risk grade B was allotted to the only trial available in this analysis.

3.3. Baseline characteristics of the patients

As shown in Table 3, the mean age of the patients varied between 58.1 and 76.6 years. Majority of the patients were males compared with females in both the study and the control groups. Hypertension and dyslipidemia were more prominent among the patients with T2DM. Several studies reported a high number of smokers among the nondiabetic patients with a few exceptions as shown in Table 3. Overall, there was no significant difference in age between CTO patients with versus without T2DM; however, comorbidities were more prominent among patients with T2DM.

3.4. Long-term clinical outcomes

This analysis showed that during a longer length of follow-up period (\( \geq 1 \) year), mortality was significantly higher in CTO patients with T2DM (OR: 1.67, 95% CI: 1.06–2.64; \( P = .03, I^2 = 0\% \)) as shown in Fig. 2. MACEs and repeated revascularization were also significantly higher in patients with T2DM (OR: 1.30, 95% CI: 1.06–1.58; \( P = .01, I^2 = 10\% \)) and (OR: 1.30, 95% CI: 1.06–1.59; \( P = .01, I^2 = 36\% \)) respectively as shown in Fig. 2. However, myocardial infarction was not significantly different (OR: 1.01, 95% CI: 0.61–1.67; \( P = .96, I^2 = 26\% \)). The overall result has been listed in Table 4.

3.5. Sensitivity analysis

Among the studies analyzing mortality, excluding each study one by one and carrying out a new analysis each time still showed mortality to significantly be higher in patients with T2DM except for study Classen2011 which when excluded, showed an insignificant result (OR: 1.29, 95% CI: 0.77–2.16; \( P = .33, I^2 = 0\% \)). Otherwise, consistent results were obtained when sensitivity analysis was carried out in all the other subgroups.

3.6. Publication bias

Publication bias across the studies was visually estimated by assessing the funnel plot which was obtained as shown in Fig. 3.

### Table 2

| Studies   | Type of study | Patients enrollment period | No of patients with T2DM (n) | No of patients without T2DM (n) |
|-----------|---------------|----------------------------|-----------------------------|--------------------------------|
| Claessen 2011 | Observational | 1998–2007                  | 202                         | 528                            |
| Felice 2006   | Observational | 2000–2003                  | 49                          | 121                            |
| Liu 2013      | Observational | 2005–2009                  | 51                          | 102                            |
| Rha 2015[11]  | Observational | 2007–2009                  | 920                         | 920                            |
| Ruiz 2015[7]  | RCT            | 2008–2011                  | 75                          | 132                            |
| Sohrabi 2011[12] | Observational | 2009–2011                  | 34                          | 123                            |
| Parachini 2016[13] | Observational | 2012–2015                  | 584                         | 724                            |
| Total no of patients (n) |                |                            | 1915                        | 2656                            |

**Note:** RCT = randomized controlled trials, T2DM = type 2 diabetes mellitus.

### Table 3

| Studies   | Mean age DM/NDM | Males (%) DM/NDM | HT (%) DM/NDM | Ds (%) DM/NDM | Cs (%) DM/NDM |
|-----------|-----------------|------------------|---------------|---------------|---------------|
| Claessen 2011 | 61.9/61.3       | 87.2/82.5        | 70.6/65.6     | 75.0/61.2     | 33.0/24.5     |
| Felice 2006   | 62.0/61.0       | 83.7/77.8        | 73.0/62.0     | 65.0/67.0     | 39.0/45.0     |
| Liu 2013      | 76.5/74.5       | 66.7/64.5        | 78.4/67.0     | 49.0/49.3     | 49.0/67.6     |
| Rha 2015      | 64.1/62.2       | 69.1/66.5        | 76.0/55.5     | 35.0/33.6     | 26.8/31.7     |
| Ruiz 2015     | 64.9/63.8       | 72.3/66.4        | 70.7/66.7     | 76.0/68.9     | 57.3/54.8     |
| Sohrabi 2011  | 58.1/58.2       | 64.7/60.6        | 58.3/58.0     | 38.2/29.5     | 20.6/36.4     |
| Parachini 2016| 65.3/65.7       | 82.5/85.5        | –             | 96.4/92.8     | 26.3/29.6     |

**Note:** Cs = current smoker, DM = diabetes mellitus, Ds = dyslipidemia, HT = hypertension, NDM = nondiabetes mellitus.

*Mean age was reported in years.*
4. Discussion

In this analysis, we aimed to compare the long-term adverse clinical outcomes of PCI which were observed in CTO patients with versus without T2DM. Current results showed mortality, MACEs and repeated revascularization to be significantly higher among patients with diabetes mellitus.

Evolution in treatment of CTO due to a revolution in medical equipment in recent years has enabled high success rate among similar patients during PCI procedures.[14] Even if randomized trials have rarely studied post PCI outcomes in diabetic patients with CTO, several observational studies have shown this invasive procedure to be safe in this particular subgroup of patients.

| Study or Subgroup | T2DM Events | T2DM Total | Non-DM Events | Non-DM Total | Odds Ratio M-H, Fixed, 95% CI | Odds Ratio M-H, Fixed, 95% CI |
|-------------------|-------------|------------|--------------|-------------|-----------------------------|-----------------------------|
| 1.1.1 Mortality   |             |            |              |             |                             |                             |
| Classen2011       | 19          | 202        | 25           | 528         | 2.09 [1.12, 3.88]            |                             |
| Felice2006        | 2           | 49         | 2            | 121         | 2.53 [0.35, 18.50]           |                             |
| Liu2013           | 3           | 51         | 3            | 102         | 2.06 [0.40, 10.60]           |                             |
| Paracini2016      | 2           | 584        | 2            | 724         | 1.24 [0.17, 8.63]            |                             |
| Rha2015           | 21          | 920        | 18           | 920         | 1.17 [0.62, 2.21]            |                             |
| Ruiz2015          | 2           | 75         | 1            | 132         | 3.59 [0.32, 40.26]           |                             |
| Sohrabi2011       | 0           | 34         | 5            | 129         | 0.33 [0.02, 6.08]            |                             |
| Subtotal (95% CI) | 1915        | 2656       | 9.6%         |             | 1.56 [1.05, 2.31]            |                             |
| Total events      | 49          | 56         |              |             |                             |                             |
| Heterogeneity: Ch² = 3.58, df = 6 (P = 0.73); P = 0% |
| Test for overall effect: Z = 2.18 (P = 0.03) |

1.1.2 Major Adverse Cardiac Events (MACEs)

| Study or Subgroup | T2DM Events | T2DM Total | Non-DM Events | Non-DM Total | Odds Ratio M-H, Fixed, 95% CI | Odds Ratio M-H, Fixed, 95% CI |
|-------------------|-------------|------------|--------------|-------------|-----------------------------|-----------------------------|
| Classen2011       | 49          | 202        | 128          | 528         | 1.00 [0.69, 1.46]            |                             |
| Felice2006        | 13          | 49         | 25           | 121         | 1.39 [0.64, 3.00]            |                             |
| Liu2013           | 15          | 51         | 13           | 102         | 2.86 [1.23, 6.59]            |                             |
| Paracini2016      | 14          | 584        | 17           | 724         | 1.02 [0.50, 2.09]            |                             |
| Rha2015           | 99          | 920        | 69           | 920         | 1.49 [1.08, 2.05]            |                             |
| Ruiz2015          | 10          | 75         | 17           | 132         | 1.04 [0.45, 2.41]            |                             |
| Sohrabi2011       | 12          | 34         | 37           | 129         | 1.36 [0.61, 3.02]            |                             |
| Subtotal (95% CI) | 1915        | 2656       | 42.4%        |             | 1.30 [1.06, 1.58]            |                             |
| Total events      | 212         | 306        |              |             |                             |                             |
| Heterogeneity: Ch² = 6.63, df = 6 (P = 0.36); P = 10% |
| Test for overall effect: Z = 2.56 (P = 0.01) |

1.1.3 Myocardial Infarction (MI)

| Study or Subgroup | T2DM Events | T2DM Total | Non-DM Events | Non-DM Total | Odds Ratio M-H, Fixed, 95% CI | Odds Ratio M-H, Fixed, 95% CI |
|-------------------|-------------|------------|--------------|-------------|-----------------------------|-----------------------------|
| Classen2011       | 5           | 202        | 29           | 528         | 0.44 [0.17, 1.14]            |                             |
| Felice2006        | 1           | 49         | 1            | 121         | 2.50 [0.15, 40.78]           |                             |
| Liu2013           | 2           | 51         | 1            | 102         | 4.12 [0.36, 46.57]           |                             |
| Paracini2016      | 8           | 584        | 4            | 724         | 2.50 [0.75, 8.34]            |                             |
| Rha2015           | 6           | 920        | 4            | 920         | 1.50 [0.42, 5.34]            |                             |
| Ruiz2015          | 0           | 75         | 3            | 132         | 0.26 [0.01, 4.81]            |                             |
| Sohrabi2011       | 3           | 34         | 9            | 129         | 1.29 [0.33, 5.05]            |                             |
| Subtotal (95% CI) | 1915        | 2656       | 7.7%         |             | 1.01 [0.61, 1.67]            |                             |
| Total events      | 25          | 51         |              |             |                             |                             |
| Heterogeneity: Ch² = 6.14, df = 6 (P = 0.23); P = 26% |
| Test for overall effect: Z = 0.05 (P = 0.96) |

1.1.4 Total Repeated Revascularization

| Study or Subgroup | T2DM Events | T2DM Total | Non-DM Events | Non-DM Total | Odds Ratio M-H, Fixed, 95% CI | Odds Ratio M-H, Fixed, 95% CI |
|-------------------|-------------|------------|--------------|-------------|-----------------------------|-----------------------------|
| Classen2011       | 30          | 202        | 93           | 528         | 0.62 [0.52, 1.28]            |                             |
| Felice2006        | 10          | 49         | 22           | 121         | 1.15 [0.50, 2.66]            |                             |
| Liu2013           | 10          | 51         | 9            | 102         | 2.52 [0.95, 6.67]            |                             |
| Rha2015           | 133         | 920        | 97           | 920         | 1.51 [1.14, 1.95]            |                             |
| Ruiz2015          | 8           | 75         | 15           | 132         | 0.93 [0.38, 2.31]            |                             |
| Sohrabi2011       | 11          | 34         | 30           | 129         | 1.58 [0.69, 3.61]            |                             |
| Subtotal (95% CI) | 1331        | 1932       | 40.3%        |             | 1.30 [1.06, 1.59]            |                             |
| Total events      | 208         | 266        |              |             |                             |                             |
| Heterogeneity: Ch² = 7.87, df = 5 (P = 0.16); P = 36% |
| Test for overall effect: Z = 2.48 (P = 0.01) |

![Figure 2](image-url) Long-term outcomes following PCI which were observed in CTO patients with versus without T2DM. CTO = chronic total occlusion, PCI = percutaneous coronary intervention, T2DM = type 2 diabetes mellitus.
Mortality 1.56 [1.05–2.31] .03 0 Fixed effects
MACES 1.30 [0.61–1.58] .01 10 Fixed effects
Total revascularization 1.30 [0.61–1.59] .01 36 Fixed effects
MI 1.01 [0.61–1.67] .96 26 Fixed effects

CI = confidence intervals, MACES = major adverse cardiac events, MI = myocardial infarction, OR = odds ratios, TLR = target lesion revascularization, TVR = target vessel revascularization.

The Bypass Angioplasty Revascularization Investigation 2 Diabetes trial showed a higher mortality rate observed in CTO patients who were treated medically and the authors suggested that the presence of CTO might not always influence total death rate following revascularization in these patients.\(^{[13]}\)

To further support this current analysis, Claessen et al.\(^{[16]}\) demonstrated that the presence of CTO in a noninfarct related artery in patients with T2DM to be strongly associated with and could be considered an independent predictor of long-term mortality (5 years follow-up).

Moreover, Safley et al.\(^{[14]}\) showed that PCI in T2DM patients with CTO was safe without causing any increase in MACEs or mortality when compared with matched patients without CTO. However, the authors clearly stated that there was no improvement in survival among these T2DM patients with CTO.

In this analysis, we have included mainly observational studies due to the lack of published trials. However, a recently published randomized trial, the CIBELES trial, showed different results compared with this analysis. CIBELES trial showed comparable outcomes in diabetic and nondiabetic patients with CTO following successful PCI.\(^{[17]}\) Mortality was also comparable between these 2 groups. However, the trial had a follow-up period of only 1 year, and involved only 75 patients with T2DM which was quite less to reach a conclusion.

Nevertheless, this analysis satisfied all the conditions to be qualified as a good meta-analysis in terms of robust results with low heterogeneity especially among the subgroup assessing mortality.

4.1. Novelty
This is the very first meta-analysis comparing the outcomes associated with PCI in CTO patients with and without T2DM. A low level of heterogeneity observed among the different subgroups could be another novelty of this analysis. In contrast to previous years, nowadays PCI is being considered safe in patients with CTO. Therefore, this analysis might provide new scientific knowledge and will help physicians predict prognosis in similar patients.

4.2. Limitations
Limitations in this analysis were the fact that a small sample size of patients were included. However, this was mainly dependent on the number of studies which were considered relevant in this analysis, as well as the total number of patients they included. Another limitation was the inclusion of observational data which might have been the source of heterogeneity during subgroup analysis. Moreover, different studies had different follow-up periods and this could be another possible limitation. In addition, the duration and type of antplatelet drugs which were used could have had an effect on the results which were obtained. Not all the studies reported the duration of antplatelet drugs.

5. Conclusions
During this longer follow-up period post PCI, mortality, MACEs and repeated revascularization in CTO patients with T2DM were significantly higher compared with similar patients without T2DM. Nevertheless, whether this hypothesis is relevant or not should be confirmed in larger trials.

References
[1] Dash D. Complications encountered in coronary chronic total occlusion intervention: prevention and bailout. Indian Heart J 2016;68:737–46.
[2] Srinivas VS, Brooks MM, Bette KM, et al. Contemporary percutaneous coronary intervention versus balloon angioplasty for multivessel coronary artery disease: a comparison of the National Heart, Lung and Blood Institute Dynamic Registry and the Bypass Angioplasty Revascularization Investigation (BARI) study. Circulation 2002;106:1627–33.
[3] Fefer P, Knuidson ML, Cheema AN, et al. Current perspectives on coronary chronic total occlusions: the Canadian Multicenter Chronic Total Occlusions Registry. J Am Coll Cardiol 2012;59:991–7.
[4] Safley DM, House JA, Rutherford BD, et al. Success rates of percutaneous coronary intervention of chronic total occlusions and long-term survival in patients with diabetes mellitus. Diab Vasc Dis Res 2006;3:45–51.
[5] Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. BMJ 2003;327:557–60.
[6] Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009;339:b2700.
[7] Ruiz-Garcia J, Teles R, Rumoroso JR, et al. Comparison between diabetic and non-diabetic patients after successful percutaneous coronary intervention for chronic total occlusions in the drug-eluting stent era. Rev Port Cardiol 2015;34:263–70.
[8] Claessen BE, Dangas GD, Godino C, et al. Long-term clinical outcomes of percutaneous coronary intervention for chronic total occlusions in patients with versus without diabetes mellitus. Am J Cardiol 2011;108:924–31.
[9] De Felice F, Fiorilli R, Parma A, et al. Outcome of diabetic and non-diabetic patients undergoing successful coronary angioplasty with bare stent of chronic total occlusion. J Cardiovasc Med (Hagerstown) 2006;7:847–51.
[10] Liu W, Wagatsuma K, Nii H, et al. Impact of diabetes on long term follow-up of elderly patients with chronic total occlusion post percutaneous coronary intervention. J Geriatr Cardiol 2013;10:16–20.
[11] Rha SW, Choi CU, Na JO, et al. Comparison of 12-month clinical outcomes in diabetic and nondiabetic patients with chronic total occlusion. J Diabetes Res 2015;2015:498765.
occlusion lesions: a multicenter study. Coron Artery Dis 2015;26:699–705.
[12] Sohrabi B, Ghaffari S, Habibzadeh A, et al. Outcome of diabetic and non-diabetic patients undergoing successful percutaneous coronary intervention of chronic total occlusion. J Cardiowasc Thorac Res 2011;3:45–8.
[13] Martinez-Parachini JR, Karatasakis A, Karmpaliotis D, et al. Impact of diabetes mellitus on acute outcomes of percutaneous coronary intervention in chronic total occlusions: insights from a US multicentre registry. Diabet Med 2017;34:558–62.
[14] Bardají A, Rodriguez-López J, Torres-Sánchez M. Chronic total occlusion: to treat or not to treat. World J Cardiol 2014;6:621–9.
[15] Damluji AA, Pomenti SF, Ramireddy A, et al. Influence of total coronary occlusion on clinical outcomes (from the bypass angioplasty revascularization investigation 2 diabetes trial). Am J Cardiol 2016;117:1031–8.
[16] Claessen BE, Hoebers LF, van der Schaaf RJ, et al. Prevalence and impact of a chronic total occlusion in a non-infarct-related artery on long-term mortality in diabetic patients with ST elevation myocardial infarction. Heart 2010;96:1968–72.