Consensus Evidence-based Guidelines for Management of Hyperglycaemia in Patients Undergoing Coronary Artery Bypass Grafting in Patients with Diabetes in India

Abhay Ahluwalia*, AK Baliarsinha**, Shashi Bhushan Gupta***, A Muruganathan****, Ashok Kumar Das*****

Abstract
Diabetes is associated with a significant risk of cardiovascular diseases (CVDs). Patients with diabetes are known to suffer from a disproportionately large burden of CVDs, in terms of higher risk, worse prognosis and more adverse outcomes. Acute coronary syndromes, including coronary artery disease, represent a large proportion of this burden and conventionally coronary artery bypass grafting (CABG) has been the mainstay of facilitating reperfusion in patients with diabetes. However, hyperglycaemia is an important factor which affects the outcomes of CABG and shows a grave impact on patients’ well-being. Thus, it is important to appropriately manage hyperglycaemia in the peri- and intra-operative periods to assure the best possible outcomes in patients with diabetes. There is scant evidence to show that oral antidiabetic drugs (OADs) or non-insulin based therapies show considerable benefit in patients undergoing CABG. Even with the use of insulin-based therapies, appropriate glycaemic targets, accurately designed algorithm to achieve such targets and specific recommendations to facilitate the appropriate use of such algorithm are important considerations. However, current international guidelines are either country-specific or fail to address context-specific needs in individual countries. In view of the growing incidence of cardiovascular diseases and diabetes in India, as a result of changing lifestyles, it is imperative upon clinicians to formulate India-specific guidelines for effective management of (CVDs). It is the endeavour of the current guideline to present recommendations based on a firm evidentiary foundation coupled with context-specific inputs from experts’ consensus opinion. These recommendations represent an effort to address the urgent need for such an exercise both in the academic as well as the clinical realm.

Introduction

Burden of diabetes
Diabetes Mellitus (DM) is a disease with increasing global incidence. International Diabetes Federation in its latest report states that, DM affects more than 371 million people worldwide, with an estimated 4.8 million deaths in 2012. In developing countries like India, which has the world’s second largest diabetes population (~63 million people), diabetes is a major health problem.1

Economic burden of diabetes
An intricate web of socio-economic and health care delivery factors influence disease outcomes and economic costs in chronic diseases like diabetes, in addition to the disease pathophysiology. According to American Diabetes Association (ADA), the total estimated cost of diabetes in United States in 2012 was $245 billion. Indian statistics indicate that total annual expenditure on diabetes care estimated around an average of INR 10,000 (US $227) in urban areas and INR 6,260 (US $142) in rural areas. It was estimated in 2007 that type 2 diabetes-mellitus (T2DM) patients with cardiovascular co-morbidity have significantly higher total healthcare costs (38.9%, $12,550 vs. $9031), total hospitalisation costs (239.8%, $4845 vs. $1426), total out-patient costs (35.3%, $3956 vs. $2925), and total prescription drug costs (15.1%, $4686 vs. $4071) compared to those without cardiovascular co-morbidity.4

Diabetes and cardiovascular risk
Diabetes is associated with significant aggravation of cardiovascular risk and this is reflected in people with diabetes constituting a significant proportion of patients facing cardiovascular diseases. According to the American Diabetes Association (ADA) in 2004, heart disease and stroke were the cause of death in 68% and 16% of diabetes-related death certificates among people aged 65 years or older, respectively. In adults with diabetes, heart disease death rates are about 2 to 4 times higher than adults without diabetes while the risk for stroke is 2 to 4 times higher.

Metabolic dysregulation in diabetes leads to chronic hyperglycaemia, dyslipidaemia and insulin resistance which leads to alteration in the function of multiple cell types including the epithelium, smooth muscle cells and platelets and augments blood coagulability. A common outcome of these atherogenic changes in the blood vessels is the coronary artery disease (CAD), whose risk increases 2 to 4 fold in patients with diabetes. When matched for other patient characteristics, diabetic patients have more extensive and diffuse CAD. Patients with diabetes currently comprise approximately one-quarter of patients referred for percutaneous coronary intervention (PCI) and experience worse outcomes than non-diabetic patients undergoing either coronary artery bypass grafting (CABG) or PCI. Nonetheless, CABG is preferable to PCI for vascular reperfusion in patients with diabetes.

*Endocrinologist, Base Hospital, Delhi Cantt.; **Dept. of Endocrinology, S.C.B. Medical College, Cuttack; ***Central Railway Headquarters Hospital, Byculla, Mumbai, Maharashtra; ****A.G. Hospital, 34, K.P.N. Colony, Tirupur, Tamil Nadu; *****Department of Medicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry
Hyperglycaemia: Role in cardiovascular pathophysiology

There are several pathophysiological features of atherosclerosis in diabetic patients that contribute to their poor prognosis and unique response to coronary revascularisation (either by CAbG or PCI). In non-ischaemic myocardium, the primary energy substrate is free fatty acids (FFAs) and during ischaemia FFAs cannot be metabolised. Thus, glucose is the preferred myocardial substrate during ischaemia. Increased levels of FFAs also impair glucose metabolism leading to hyperglycaemia, which leads to the formation of advanced glycation end-products (AGE) and its receptor (RAGE). RAGE increases inflammation by up-regulation of NF-kB (nuclear factor-kappa B), AP-1 (activated protein), EGR-1 (early growth response). Secretion of insulin normally suppresses all three inflammatory mediators. Hyperglycaemia also directly affects endothelial function where endothelial nitric oxide synthase (eNOS) generates low levels of nitric oxide (NO), which has protective properties. In virtually every cell type, iNOS (inducible) generates high NO concentrations, which are pro-inflammatory.12

Overview of guidelines for management of hyperglycaemia during CAbG

The American College of Cardiology Foundation/American Heart Association (ACCF/AHA) task force for practice guideline on CAbG recommends the use of CAbG for vascular reperfusion in patients with diabetes and lays emphasis on the maintenance of good perioperative glycaemic control.13 Recommendations relating to the management of hyperglycaemia during CAbG in specific and ACS in general are also found as a part of the National Heart Foundation of Australia Cardiac Society of Australia and New Zealand (NHFACS) guidelines,14 Scottish Intercollegiate Guidelines Network (SIGN) guideline,15 and guideline from the European Society of Cardiology (ESC).16 The society of thoracic surgeons (STS) practice guideline series include a guideline on blood glucose management during adult cardiac surgery.17 Additionally the AACC/AHA guideline on the management of unstable angina/non-ST-elevation myocardial infarction (UA/NSTEMI) provides important pointers on clinical practices for managing hyperglycaemia during MI management.18

Rationale for India specific guidelines

Existing guidelines focus on the management of hyperglycaemia in patients at their respective regions. However, the Indian population is a diverse group of people with varying genetic and demographic profiles. Furthermore, the incidence of diabetes and CV diseases on the upswing due to changing guidelines make them potential public health catastrophes without timely intervention. These guidelines do not specifically address the clinical questions about the considerations related to diabetes during and after CAbG. Due to these peculiarities in the Indian scenario, existing guidelines cannot be widely used in the Indian scenario. This current consensus guideline aims to provide specific recommendations based on published data for proper management of hyperglycaemia in patients with CAbG in India.

Methodology

A systematic review of literature from medical databases was conducted to provide the best possible evidence base for the recommendations. Existing guidelines, meta-analyses, cross sectional studies, systematic reviews and key cited articles related to management of hyperglycaemia in patients undergoing CAbG were reviewed by a group of doctors and recommendations relevant to Indian scenario were framed.

The recommendations were discussed at the National Insulin Summit held in August 2013, by an expert panel of physicians, endocrinologists and key opinion leaders. At this summit, recommendations for each section of the guidelines, and overall recommendations were agreed upon. Where there was little or no evidence, the committee relied on experience, judgement and consensus to make their recommendations. The consensus document was drafted and circulated for further feedback from the participants and others who could not attend.

Grading system

The current consensus guidelines have been developed in accordance to the AACE protocol for standardised production of clinical practice guidelines.19 Recommendations are organised by topic and are assigned evidence level (EL) ratings on the basis of the quality of supporting evidence, all of which have also been rated for strength. Recommendations are based on clinical importance and graded as A (strongly recommend), B (intermediate), C (weak) and D (not evidence-based). The evidence levels are coupled by four intuitive levels of evidence: 1, 2, 3, 4. They have been positioned on the basis of available evidence to be used for grading recommendations as follows.

- “1”: Meta-analysis of randomised controlled trials, randomized controlled trials
- “2”: Meta-analysis of nonrandomised prospective or case-controlled trials, nonrandomised controlled trial, prospective cohort study, retrospective case-control study
- “3”: Cross-sectional study, surveillance study (registries, surveys, epidemiologic study, retrospective chart review, mathematical modelling of database), consecutive case series, single case reports
- “4”: No evidence (theory, opinion, consensus, review, or preclinical study)

Current Consensus Evidence-based Guidelines

CAbG vs. PCI in patients with diabetes

Existing guidelines

The common modes of coronary reperfusion i.e. PCI and CAbG are recommended in distinct clinical scenarios. The 2011 ACCF/AHA guidelines state that CAbG is the preferred treatment for: disease of the left main coronary artery (LMCA), disease of all three coronary vessels (LAD, LCX and RCA), diffuse disease not amenable to treatment with a PCI, other high-risk patients such as those with severe ventricular dysfunction (i.e. low ejection fraction), or diabetes mellitus.13 This is further stressed by the AACE/AHA guideline of the management of UA/NSTEMI and the ESC guideline which recommend CAbG for patients with diabetes, especially when coincident with multivessel disease.14,18

Evidence base

Studies prove that CAbG is the preferred option of coronary reperfusion compared to PCI in patients with diabetes.20 The FREEDOM trial in 2012 showed that the relative advantage of CAbG over PCI was based on differences in rates of both myocardial infarction (P < 0.001) and death from any cause (P = 0.049).21 These results confirm trends from a previous randomised trial (Coronary Artery Revascularisation in Diabetes-CARDia)20 and the Bypass Angioplasty Revascularisation Investigation (BARI) study which reported significantly higher cumulative survival rates in patients with diabetes, to CAbG compared to
PCI. The BARI trial included 1,829 patients with stable ischemic heart disease before randomisation to PCI or CABG. Diabetic patients (n = 353) in the BARI trial showed a 15% absolute survival advantage for CABG (P = 0.003) at 5 years.22

The CARDia trial was a randomised, non-inferiority trial that directly compared CABG versus PCI with predominant DES (drug eluting stents) use (69%) in diabetic patients. At one-year follow-up, repeat revascularisation procedures were more frequent with PCI (9.9%) than CABG (2.0%; P < 0.001).23 The SYNTAX study which tested the non-inferiority of PCI against CABG showed that despite a higher rate of stroke in CABG, rates of major adverse cardiac or cerebrovascular events at 12 months were significantly higher in the PCI group (17.8%, vs. 12.4% for CABG; P = 0.002), as a result of an increased rate of repeat revascularisation (13.5% vs. 5.9%, P < 0.001). It concluded that CABG remains the standard of care for patients with three-vessel or left main CAD, compared to PCI.24 The major advantage of CABG over PCI is the ability to achieve complete revascularisation. The superiority of CABG over angioplasty in providing complete revascularisation is exemplified in the BARI study itself. In this study 3.1 grafts could be placed per patient undergoing CABG, whereas the mean number of successfully treated lesions in the PCI group was two. When multi-vessel angioplasty is performed, multiple treatment sites can independently result in restenosis. The poor outcome of diabetic patients undergoing PCI may be mediated, in part, by the frequent occurrence of incomplete revascularisation.25

Recommendations

- It is recommended that for patients with diabetes requiring vascular reperfusion following coronary atherosclerosis, CABG should be preferred over PCI (Grade A; EL 1).10,13
- CABG is a preferred option due to its cost effectiveness, lower complexity and improved clinical outcomes in long term (Grade A; EL 1).21,26

Effect of hyperglycaemia in patients with diabetes undergoing CABG

Existing guidelines

While CABG is the preferred technique for coronary reperfusion in patients with diabetes, post-CABG outcomes are significantly adversely impacted by diabetes.27 Patients with diabetes have worse hospital and long-term outcomes after CABG.27-32 Peri-operative hyperglycaemia, especially in the initial 24-hr period following surgery, is known to adversely affect post-CABG outcomes, such as post-operative infection rate, mortality and morbidity.33-35 The NHFACs guideline recommends that good glycaemic control should be obtained in patients being managed for Non-ST elevation acute coronary syndrome during hospital stay and after discharge.14 The SIGN guideline of ACS recommends immediate intensive blood glucose control for at least 24 hour in MI patients with diabetes or showing hyperglycaemia.15 ESC guideline stresses on the maintenance of glycaemic control along with frequent monitoring of BG and screening for diabetes at admission.16 STS has published an exclusive guideline dealing with management of hyperglycaemia during cardiac surgeries.17

Evidence base

Lazar et al. investigated the effect of tight glycaemic control (serum glucose, 125 to 200 mg/dL) with GIK or standard therapy (serum glucose < 250 mg/dL) compared to intermittent SC insulin. GIK patients had lower serum glucose levels, a lower incidence of atrial fibrillation, a shorter postoperative length of stay, and a 2-year post-operative survival advantage with lower recurrent ischaemia.36 In another retrospective analysis of prospectively collected data both intra-operative and post-operative glucose concentrations, predicted risk for mortality and morbidity. Increased postoperative glycaemic variability was associated with increased risk for adverse outcomes. A summary of the effect of peri-operative glucose concentrations and glycaemic variability in predicting outcomes after cardiac surgery is shown in Table 1.37 Timmer et al investigated the association between thrombolysis in myocardial infarction (TIMI) flow grade and hyperglycaemia in patients with STEMI (ST-segment-elevation MI) prior to reperfusion therapy.25 Significantly more patients with hyperglycaemia had TIMI flow grade 0 vs. grades 1 to 3.25

Recommendation

- Appropriate glycaemic management should be considered an important factor in improving outcomes for patients with diabetes undergoing CABG (Grade A; EL 1).13,36

Appropriate glycaemic targets and monitoring

Existing guidelines

Appropriate glycaemic management is essential in patients undergoing CABG for patients with or without diabetes. The 2011 ACCF/AHA guidelines on CABG recommend a blood glucose target of ≤ 180 mg/dL to “reduce the incidence of adverse events, including deep sternal wound infection, after CABG”.13 The same blood glucose level has been recommended by STS for patients with diabetes undergoing cardiac surgery, as well as in those patients without diabetes. Intra-operative glycaemic control using intravenous insulin infusions is recommended in cardiac surgery patients without diabetes at glucose values ≥ 180 mg/dL.17 While the STS guidelines do not mention prospective monitoring of patients, they stress on the need for optimisation of glycaemic control prior to cardiac surgery which involves pre-

---

**Table 1: Effect of intra-operative and post-operative hyperglycaemia in patients undergoing coronary artery bypass graft**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intra-operative</th>
<th>Post-operative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BG &gt; 200 mg/dL</td>
<td>BG ≤ 200 mg/dL</td>
</tr>
<tr>
<td>Mortality</td>
<td>21 (3.0)</td>
<td>51 (1.4)</td>
</tr>
<tr>
<td>Cardiac morbidity</td>
<td>10 (1.4)</td>
<td>34 (0.9)</td>
</tr>
<tr>
<td>Prolonged intubation</td>
<td>78 (11.1)</td>
<td>212 (5.9)</td>
</tr>
<tr>
<td>Renal morbidity</td>
<td>24 (3.4)</td>
<td>58 (1.6)</td>
</tr>
<tr>
<td>Serious infection</td>
<td>36 (5.1)</td>
<td>77 (2.1)</td>
</tr>
<tr>
<td>Neurologic morbidity</td>
<td>12 (1.7)</td>
<td>45 (1.3)</td>
</tr>
<tr>
<td>Overall morbidity</td>
<td>96 (13.7)</td>
<td>271 (7.52)</td>
</tr>
</tbody>
</table>

*BG: Blood Glucose*
Table 2: Portland protocol

<table>
<thead>
<tr>
<th>Blood glucose (mg/dL)</th>
<th>IV insulin bolus (U)</th>
<th>Initial insulin rate (U/h) (circle one)</th>
<th>T2DM pre-operatively</th>
<th>T1DM pre-operatively</th>
</tr>
</thead>
<tbody>
<tr>
<td>80-119</td>
<td>0</td>
<td>0.5</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>120-179</td>
<td>0</td>
<td>1.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>180-239</td>
<td>0</td>
<td>2.0</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>240-299</td>
<td>4</td>
<td>3.5</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>300-359</td>
<td>8</td>
<td>5.0</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>≥360</td>
<td>12</td>
<td>6.5</td>
<td>8.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

IV: intravenous; T2DM: Type 2 diabetes mellitus; T1DM: Type 1 diabetes mellitus

*Conditions for action to be taken based on BG level (mg/dL)
- If BG < 50: Stop insulin; give 25 mL D50; recheck BG in 30 minutes.
- If BG < 100: Stop insulin, recheck BG in 30 min, restart at 50% of previous rate when BG > 150 mg/dL, unless dose is < 0.25 U/hr.
- If BG > 100: Δ rate by 0.5 U/hr.
- If BG > 125: Δ rate by 0.5 U/hr.
- If BG > 175: Δ rate by 0.5 U/hr.

Evidence base

There is a paucity of studies investigating the possible role of OADs in peri-operative glycaemic management during CABG. A study investigated the use of metformin as adjunct therapy to insulin in peri-operative glycaemic management during CABG, compared to insulin. The study reported that mean blood glucose levels were not significantly different in the two groups at the beginning of the ICU admission; however, significant reduction in the metformin-insulin group was seen 12 hours later (P < 0.05). In the insulin-metformin group, mean doses of potassium and insulin demand as well as mean number of episodes of hyperglycaemia, hypoglycaemia, and glucose levels out of the accepted range were significantly lower (P < 0.05). Certain OADs like, glibenclamide have concerns about their myocardial effects and a pre-operative shift from glibenclamide to insulin has been shown to improve cardiovascular outcomes after CABG.

Recommendations

- Due to the lack of sufficient evidence pointing to significant benefits in using OADs for peri-operative glycaemic management during CABG in patients with diabetes, the use of OADs even as adjunct therapy is not recommended (Grade B; EL 4).
- Known diabetes patients well-controlled on OADs with an HbA1c < 7% and without any intervention can be shifted to OADs after 7 days or at the time of discharge (Grade A; EL 4).
- Known diabetes patients on OADs with an HbA1c < 7.5% undergoing CABG/PCI should be continued on insulin therapy up to 6 weeks from discharge and the patient should be reassessed for continuation of insulin and in absence of any contraindications to OADs, can be switched from insulin to OADs (Grade A; EL 4).

Insulin in peri-operative glycaemic management in patients with diabetes undergoing CABG

Existing guidelines

Insulin therapy has been shown to be helpful in providing feasible and efficient, tight perioperative glycaemic control with minimal risks for hypo- and hyperglycaemia in patients with or without diabetes undergoing off-pump CABG. The 2011 ACCF/AHA guidelines also recommend the use of continuous intravenous insulin infusion for peri-operative glycaemic management in patients undergoing CABG. The STS guideline recommends the use of continuous insulin infusion for peri-operative glycaemic control and further suggests its continual for > 24 hours postoperatively.

Evidence base

The contemporary view of the action of insulin, based on studies in humans and animal models that have demonstrated cardioprotective, neuroprotective, and anti-apoptotic effects is that several mechanisms may explain the potential beneficial effects of insulin, including enhanced vasodilation, reduced oxidative stress, reduced inflammation, platelet inhibition, and improved fibrinolysis. The administration of insulin continuously either by the subcutaneous route or intravenously has been investigated in studies. Furnary et al. demonstrated that...
**Table 3: Comparison of recommendations from current consensus guidelines and existing guidelines**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Current guideline</th>
<th>STS</th>
<th>ESC</th>
<th>ACCF/AHA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG vs. PCI in patients with diabetes</td>
<td>CABG is recommended</td>
<td>Advantage of CABG over PCI noted</td>
<td>CABG is recommended over PCI</td>
<td>CABG is recommended over PCI</td>
</tr>
<tr>
<td>Glycaemic control recommended as an important concern for those undergoing CABG?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Prospective monitoring of blood glucose</td>
<td>Hourly monitoring for the first 12 hours, followed by 4 hourly monitoring if steady glucose control is observed</td>
<td>Frequent blood glucose monitoring depending on clinical condition</td>
<td>Prospective testing for diabetes, hyperglycemia in all patients with non-ST elevation acute coronary syndrome</td>
<td>-</td>
</tr>
<tr>
<td>Blood glucose targets</td>
<td>120–180 mg/dL</td>
<td>≤ 180 mg/dL</td>
<td>&lt; 180–200 mg/dL</td>
<td>≤ 180 mg/dL</td>
</tr>
<tr>
<td>Role of OADs</td>
<td>No OADs in peri-operative condition, but patients with HbA1c &lt; 7% on OADs alone to resume after 7 days or at discharge</td>
<td>No OADs in peri-operative condition, OADs can be resumed if glucose targets are met and there are no contraindications</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Role of insulin</td>
<td>Only insulin recommended for peri-operative glucose control</td>
<td>Only insulin recommended for peri-operative glucose control</td>
<td>Only insulin recommended for peri-operative glucose control</td>
<td>Only insulin recommended for peri-operative glucose control</td>
</tr>
<tr>
<td>CII vs. SC insulin</td>
<td>CII recommended</td>
<td>CII recommended</td>
<td>CII recommended</td>
<td>CII recommended</td>
</tr>
<tr>
<td>Blood glucose threshold for CII initiations</td>
<td>180 mg/dL</td>
<td>180 mg/dL</td>
<td>-</td>
<td>180 mg/dL</td>
</tr>
<tr>
<td>Duration of CII</td>
<td>3 days</td>
<td>Up to 3 days or duration of ICU stay</td>
<td>-</td>
<td>Results of studies administering CII till 3 days noted</td>
</tr>
<tr>
<td>Transition from CII</td>
<td>Transition from CII to SC insulin when patients start oral feeding and reach target BG</td>
<td>Transition from CII to SC insulin using institutional protocols</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cardiovascular medication</td>
<td>All cardiovascular medications to be used as per requirement similar to non-diabetic patients</td>
<td>Antithrombotic treatment is indicated as in non-diabetic patients</td>
<td>All cardiovascular medications to be used as per requirement similar to non-diabetic patients</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations**: ACCF-AHA: American College of Cardiology Foundation/American Heart Association; BG: Blood glucose; STS: Society of thoracic surgeons; ECS: European Cardiology Society; OADs: Oral anti-diabetic drugs; CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; CII: Continuous insulin infusion; SC: Subcutaneous; ICU: Intensive care unit

Continuous intravenous insulin infusion was associated with lower mean post-operative glucose levels and overall mortality than intravenous administration starting from the day of surgery through the second day post-operatively. In other studies continuous insulin infusion has been shown to be associated with a reduced post-surgical infection, length of stay, morbidity and mortality. Several insulin infusion protocols are currently in use in ICU and peri-operative settings for glycaemic control. Commonly used protocols include “Portland protocol”, “Markovitz protocol” and “Glucommander protocol”. The commonly used intravenous insulin infusion protocol is the “Portland protocol” (Table 2).

**Recommendations**

- Continuous intravenous insulin infusion (CII) should be used as the mainstay of peri-operative glycaemic management in patients with diabetes undergoing CABG (Grade A; EL 2).
- CII should be initiated in patients if the BG level is > 180 mg/dL for 2 (1 hourly) consecutive readings (Grade A; EL 4).
- CII should be continued up to 24 hours or till the last 4 values are between 120-180 mg/dL and the patient starts oral feeding, then the patient can be switched to SC insulin with basal-bolus regimen (Grade A; EL 4).

- For diabetic patients undergoing CABG, CIII should be initiated (Portland Protocol) during the surgical procedure and continued till the third postoperative day. The dose and infusion rate of IV insulin in the pre- and peri-operative conditions should be followed with BG monitoring as per the Table 2 (Grade A; EL 4, 51).
- Monitoring must be done once hourly, until BG of 125-175 mg/dL is reached or if a change in BG < 15 mg/dL is observed while the infusion rate is unchanged for 4 hours. Subsequently a two-hourly monitoring is sufficient, which can be stopped on the third day post-operatively. However, when patients are being weaned off vasopressors, a half-hourly rate of monitoring is recommended (Grade A; EL 4).

**Cardiovascular medications and diabetes management**

**Existing guidelines**

ESC guidelines recommend the initiation of antithrombotic therapy in patients with diabetes similar to other patients. NICE and NHFAC guidelines recommend prasugrel as an alternative to aspirin in patients with diabetes undergoing PCI.

**Evidence base**

Post-operative management of CAD includes pharmaceutical
interventions including beta-blockers, angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers, antiplatelet therapy, antihyperlipidaemics etc. Careful consideration of the patients’ diabetic status must be made in order to optimise the management approach. Platelet hyper reactivity observed in DM patients persists under single and dual antiplatelet treatments, a phenomenon termed ‘resistance’. The agents currently approved for antiplatelet therapy include aspirin, adenosine diphosphate (ADP) P2Y12 receptor antagonists (clopidogrel, prasugrel etc.).

**Recommendation**

- In patients with diabetes all cardiovascular medications like beta blockers, statins, antiplatelet agents, angiotensin-converting enzyme inhibitors should be used as per non diabetic patients (Grade A; EL 1).13,55-60

**Summary**

Diabetes is associated with a significant risk of cardiovascular diseases, leading to a large burden of CAD in people with diabetes. Given the metabolic and pathophysiological changes unique to diabetes, the management of CAD in patients with diabetes must be suitably customised. Suitable management of CAD is both affected by and affects patients’ diabetic status. However, despite the availability of good quality evidence from studies, no diabetes-specific guidelines have been evolved for CAGB leading to divergent trends in clinical practice. The current guideline on CAGB in patients with diabetes is an attempt to address this lacuna in medical practice and its comparison with other guidelines is presented (Table 3). With a focus on high quality evidence it is hoped that the adoption of the current guideline in Indian medical practice will help in delivering better healthcare to a vulnerable patient population.

**Proposed Algorithm for Management of Hyperglycaemia in Patients Undergoing CABG**

Based on the consensus guidelines developed for management of hyperglycaemia in patients undergoing CAGB, an algorithm has been proposed (Figure 1).

**Acknowledgements**

The authors thank Jeevan Scientific Technology Limited, Hyderabad, India, for providing writing assistance in the development of this manuscript.

**References**


58. Davidson PC, Steed RD, Bode BW. Glucommander: a computer-directed intravenous insulin system shown to be safe, simple, and effective in 120,616 h of operation. *Diabetes Care* 2005;28:2418-23.


