



# Avoiding Postoperative Complications is Key to Improving CABG Quality



## Improving the Quality of Coronary Artery Bypass Graft (CABG) Surgery

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# CABG Quality Impacts Multiple Domains

Improving CABG quality has important implications not only for superior clinical outcomes but for hospital reimbursement, patient satisfaction and cardiac surgery provider reputation.

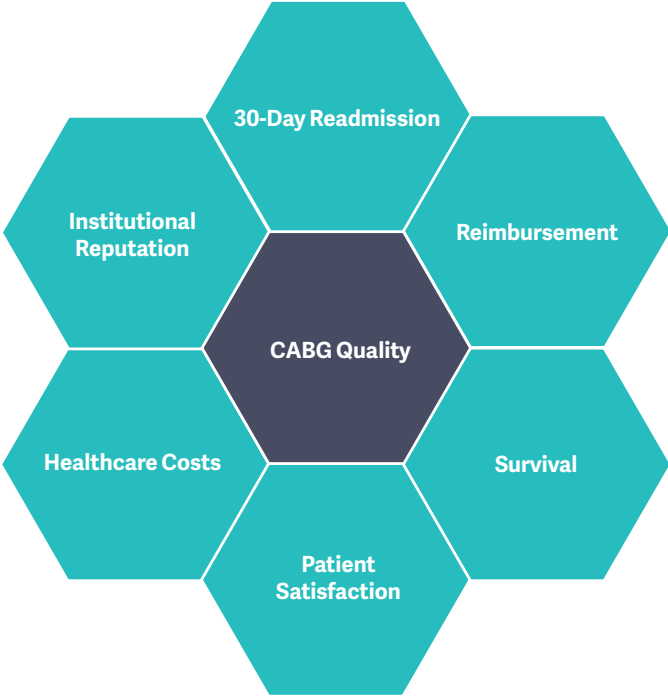
Escalating healthcare costs, disparities in outcomes across centers and lack of a demonstrable relationship between increased spending and superior outcomes have focused attention on the need for improving healthcare quality and cost-effectiveness. Coronary artery bypass graft (CABG) surgery is under particular scrutiny due to the large number of procedures performed, high costs and potential for serious patient harm.<sup>1-4</sup>

Cardiothoracic surgery has been at the forefront of quality monitoring and improvement efforts. Registries have been established worldwide to monitor and report cardiac surgery outcomes for the purpose of improving the quality of care provided.<sup>5,7</sup> Efforts to encourage quality improvement and enable patients to make informed treatment choices have resulted in public reporting of complication rates as well as consumer-directed scorecards and hospital ratings.<sup>8</sup> Further, financial incentives and penalties have been instituted by payers to encourage meeting quality benchmarks and reducing preventable complications.<sup>3</sup>

### Increased Patient Risk Makes Improving CABG Quality Challenging

Providing high-quality and cost-effective surgical treatment is increasingly challenging as prevalence of diabetes, older age, obesity, pre-existing lung disease and other risk factors known to correlate with poor outcomes and serious complications continue to rise.<sup>9,10</sup> While advances in care have led to continued reduction in mortality despite increased patient risk, postoperative complications continue to hamper outcomes and increase healthcare costs.<sup>11,12</sup>

Figure 1. The Domains Impacted by CABG Quality



**Table 1. Prevalence of Selected CABG Patient Co-Morbidities and Impact on Outcomes***Adapted from Shahian et al. (2009)*

Co-Morbidity	% Patients	% Patients Experiencing Adverse Outcome					
		Mortality	Stroke	Renal Failure	Prolonged Ventilation	DSWI	Reoperation
Age > 75	22.0	4.7	2.3	6.4	13.9	0.5	7.5
Diabetes, Non-Insulin	25.2	2.3	1.6	4.3	10.1	0.5	5.2
Diabetes, Insulin	10.9	3.6	1.8	7.1	13.9	1.0	6.5
Cerebrovascular Disease	13.6	4.0	2.9	5.8	14.0	0.6	7.2
Body Mass Index > 35	14.2	2.3	1.2	5.2	12.0	0.8	4.9
Renal Failure	5.4	7.2	2.7	14.7	22.5	1.0	9.9
EF 25-34	7.4	4.4	2.1	6.1	17.6	0.6	7.6
Peripheral Vascular Disease	15.5	4.4	2.3	6.1	14.4	0.7	7.5
3-Vessel Disease	75.7	2.5	1.5	4.0	10.4	0.4	5.5
Left Main Disease	28.1	3.0	1.5	4.3	11.9	0.5	5.9
Prior CABG	4.7	5.3	1.6	5.8	14.7	0.5	20.9
Emergent Status	4.4	8.1	2.6	8.3	29.6	0.7	10.4

### Reducing Postoperative Complications is Key to Improving CABG Quality

A number of CABG quality metrics have been proposed. There is a general consensus that a core group of adverse outcomes are central to patient wellbeing and can enable comparison of providers' and institutions' quality of care.<sup>5,6</sup> These outcome measures and procedural advances that favorably impact them, particularly in high-risk patients, are considered below.

#### Operative (30-Day) Mortality

CABG mortality rates continue to decline as a result of surgical innovations and quality improvement initiatives. Current estimates place overall 30-day mortality for isolated CABG at 2%, and cardiothoracic leadership has challenged the surgical community to achieve a rate of 1% or less in the next several years.<sup>13</sup> Despite the decline in overall mortality, some CABG patients are at extreme preoperative risk due to multiple, severe co-morbidities, with 25% of patients having predicted 30-day mortality rates greater than 2% and 5% having predicted mortality in excess of 6%.<sup>14</sup>

Large propensity-matched comparisons document a significant reduction in 30-day mortality for patients undergoing off-pump coronary artery bypass (OPCAB).<sup>15</sup> This benefit is driven by the disproportionate positive impact on patients at

highest operative risk, in whom observed mortality is reduced by more than 50%.<sup>15</sup>

CABG mortality is more than doubled in patients with heart failure.<sup>16</sup> While OPCAB has shown a mortality benefit in patients with severe left ventricular dysfunction, its application may be limited by a 5% rate of unplanned conversions to cardiopulmonary bypass in this patient subset.<sup>17</sup> There is evidence to suggest that use of intra-aortic balloon pump (IABP) support during off-pump CABG can provide hemodynamic support assisting in maintaining hemodynamic stability.<sup>18</sup> Increasing evidence suggests that patients with left ventricular dysfunction may benefit from an on-pump beating-heart approach to revascularization that provides hemodynamic support while eliminating aortic cross clamping and cardioplegic arrest.<sup>19</sup> In addition, preoperative intra-aortic balloon pump insertion has also been demonstrated to substantially reduce mortality in high-risk patients undergoing elective CABG.<sup>20</sup>

Urgent CABG is performed to minimize the chance of further clinical deterioration in cases such as congestive heart failure, acute MI, and unstable angina with intravenous nitroglycerin. Urgent CABG increases the risk of MI and prolonged hospital stay in comparison to elective CABG. Moreover, preoperative low EF and prolonged CPB time are associated with a significant increase in the risk of mortality

after urgent CABG.<sup>21</sup> IABP offers therapeutic value in multiple settings, including preoperative stabilization of the patient experiencing ischemic cardiogenic shock and hemodynamic rescue intraoperatively or postoperatively. Alternative support devices are available when higher levels of support are required.<sup>22</sup>

## Stroke

Stroke is an infrequent yet devastating complication of CABG. While advances in preoperative risk assessment and surgical technique have reduced stroke incidence,<sup>23</sup> approximately 1% of CABG patients suffer stroke.<sup>24</sup> Aortic manipulation has been identified as a major contributor to stroke.<sup>23,25</sup> Almost half of CABG patients have moderate aortic atherosclerosis, and nearly 10% have severe aortic disease.<sup>26</sup> Degree of aortic disease is strongly correlated with stroke risk, with stroke rates of 19%-45% reported for patients with severe aortic atheroma who undergo conventional CABG.<sup>26</sup>

Revascularization approaches that avoid or reduce aortic manipulation ("no touch" OPCAB using pedicled internal mammary artery and Y grafts, OPCAB using clampless proximal anastomosis devices, and on-pump beating-heart CABG) have been associated with significant reductions in stroke compared with conventional arrested heart approaches.<sup>23,25</sup> Investigations into the timing of CABG-related strokes document that a substantial proportion of strokes occur in the postoperative period, approximately 2-5 days following uneventful CABG surgery.<sup>23</sup> New-onset, postoperative atrial fibrillation (POAF) has been identified as a significant risk factor for postoperative stroke, increasing the occurrence by at least two-fold.<sup>27,28</sup> Emerging evidence suggests that successful intraoperative isolation of the left atrial appendage is associated with reduction in late stroke attributable to new-onset POAF.<sup>28</sup>

## Acute Renal Failure/Injury

Acute kidney injury (AKI) is a common postoperative complication of CABG. AKI is associated with increased mortality, with mortality accruing according to severity of kidney dysfunction.<sup>29,30</sup> AKI following coronary artery bypass surgery is also associated with greater risk for chronic kidney disease.<sup>29,30</sup> Further, patients who develop AKI following CABG have 2-3 times higher 30-day readmission rates than those who do not.<sup>31</sup>

Hypoxia, low hemoglobin and inflammation are key contributors to the development of AKI following CABG.<sup>29,30</sup> And, odds of postoperative AKI are doubled with red blood cell transfusion.<sup>30</sup> Intraoperative strategies aimed at mitigating AKI include minimizing hemodilution, hypoxia and systemic inflammation.<sup>29,30</sup> Similar decreases in incidence of postoperative renal dysfunction have been demonstrated with avoidance of cardiopulmonary bypass<sup>32</sup> and use of miniaturized extracorporeal circulation (MECC). MECC minimizes the inflammatory response, coagulopathy and hemodilution by reducing blood contact with foreign surfaces and air, as well as substantially reducing priming volume.<sup>33</sup>

## Prolonged Postoperative Ventilation

One of the main factors that can predict a patient's risk for postoperative respiratory complications is the underlying lung status. Patients with preoperative ventilation problems also have increased risk for postoperative problems.<sup>10</sup>

Prolonged postoperative ventilation is associated with increased mortality and a variety of postoperative complications.<sup>34,35</sup> Though causes of prolonged ventilation are multifactorial, identified risks include intraoperative atelectasis, hypoxia and prolonged sedation from anesthetic agents.<sup>34,36</sup>

Fast-track cardiac anesthesia protocols have shown a beneficial impact on rates of prolonged ventilation.<sup>35</sup> Advanced anesthesia systems that enable active hypoxia monitoring, optimal dosing of anesthetic agents and lung-protective ventilation, including low ventilation pressures (based on predicted body weight vs. actual body weight), lung recruitment maneuvers and positive end-expiratory pressure (PEEP), may be helpful in furthering efforts to limit prolonged postoperative ventilation. A ventilatory strategy that includes protective tidal volumes, higher PEEP levels, ventilation during CPB, and pre-emptive non-invasive ventilation (NIV) may reduce inflammatory response, thereby decreasing postoperative complications.<sup>37</sup>

A recent study shows that 29% of patients experience weaning failure due to diaphragm dysfunction, which extends time on mechanical ventilation by up to 16 days.<sup>38</sup> A recent editorial<sup>39</sup> suggested that prevention of disuse atrophy and high breathing efforts are the cornerstone of diaphragm-protective mechanical ventilation, where monitoring of diaphragmatic electrical activity (Edi) is proposed as a method to target physiological loading of the diaphragm by adjusting the level of inspiratory ventilator support and/or dose of sedatives until the patient has been liberated from the ventilator.

## Surgical Site Infection

Between 2% and 20% of CABG procedures are complicated by surgical site infection (SSI),<sup>40</sup> and these infections are more frequent in obese and diabetic patients. Efforts to decrease the incidence and costs associated with hospital-acquired infections include mandatory reporting of SSI rates and reduced reimbursement for institutions that exceed pre-defined rates of preventable infections.

Deep sternal wound infection (DSWI) complicates approximately 2% of CABG procedures and is associated with doubled mortality as well as large increases resource utilization and costs.<sup>41</sup>

Development of sternal wound infections is associated with perioperative hypoxia and red blood cell transfusions,<sup>41</sup> suggesting a beneficial impact of intraoperative techniques that avoid hemodilution. In addition, reduced incidence of deep sternal wound infections has been reported following off-pump revascularization.<sup>32</sup>



Impaired healing of saphenous vein graft (SVG) harvest wounds has been reported in up to 24% of CABG patients.<sup>42</sup> The vast majority of SVG harvest infections are diagnosed after discharge and have been shown to double rates of readmission.<sup>43</sup> Endoscopic vessel harvest (EVH) methods reduce incidence of harvest wound infections by approximately 70% without compromising long-term revascularization outcomes.<sup>44</sup>

## Re-Exploration

Surgical re-exploration for bleeding is an infrequent but highly morbid complication of CABG surgery. The Society of Thoracic Surgeons Adult Cardiac Surgery Database reports that repeat surgery for bleeding following CABG occurs at a rate of 2.39% and is associated with a more than 4-fold increase in operative mortality, a 3-fold increase in pneumonia and septicemia, and a nearly 5-fold increase in prolonged ventilation.<sup>45</sup>

Reoperation for bleeding is more frequent in patients who receive potent antiplatelet agents (i.e., thienopyridine or glycoprotein IIb/IIIa agents) within 24 hours of surgery and in patients who undergo emergent or emergent salvage surgery.<sup>45</sup> OPCAB is associated with significantly lower rates of reoperation for bleeding than on-pump CABG, including patients who receive clopidogrel before surgery.<sup>45</sup>

Reoperation for surgical hemostasis is related to surgical site bleeding in two-thirds of patients undergoing adult cardiac surgery, suggesting that most events could be prevented by meticulous surgical technique and systematic inspection of potential bleeding sites just prior to chest closure.<sup>46, 47</sup>

## Post-operative Atrial Fibrillation

Post-operative atrial fibrillation (POAF) occurs in approximately 20% of isolated CABG cases. New onset atrial fibrillation following cardiac surgery is associated with doubled risk-adjusted mortality, prolonged ICU and hospital lengths of stay, and more frequent 30-day readmissions.<sup>48</sup> POAF is increasingly recognized as risk factor for thromboembolic events and is associated with a 2-fold increase in postoperative stroke.<sup>27, 48</sup> POAF will present a mounting challenge as the average age of the CABG population continues to climb.<sup>48</sup>

Efforts are underway to clarify the most cost-effective protocols to reduce POAF incidence. Revascularization approaches that avoid cardiopulmonary bypass<sup>32</sup> or use minimized extracorporeal circuits<sup>33</sup> have shown beneficial impacts.

## Transfusions

Many cardiac surgery quality improvement efforts focus on reducing patient exposure to perioperative blood products. Transfusion of red blood cells has been associated with risk-adjusted increases in mortality (OR 1.77;  $p < .0001$ ),

renal failure (OR 2.06;  $p < .0001$ ), prolonged ventilatory support (OR 1.79;  $p < .0001$ ), serious infection (OR 1.76;  $p < .0001$ ), cardiac complications (OR 1.55;  $p < .0001$ ), and neurologic events (OR 1.37;  $p < .0001$ ).<sup>49</sup> Additional evidence indicates that the deleterious effects of red blood cell transfusion are exacerbated in the setting of perioperative anemia, resulting in a double-negative exposure that is associated with significantly greater harm than exposure to either anemia or transfusion alone.<sup>50</sup>

Minimizing blood loss and hemodilution are important in avoiding anemia requiring red blood cell transfusion. Transfusion rates are reduced with MECC, a miniaturized extracorporeal circuit that reduces priming volumes and associated hemodilution.<sup>33</sup> OPCAB has also consistently demonstrated significantly lower rates of red blood cell transfusion.<sup>32</sup>

## Readmission

Hospital readmissions following CABG contribute substantially to overall healthcare costs and have been targeted for reduced reimbursement from CMS beginning in 2017. While process shortcomings, such as discontinuities in transition to discharge, have been identified as contributing to increased readmission, the most common cause of readmission within 30 days of CABG surgery is procedural complications, with postoperative infection and other complications accounting for 25% of readmissions.<sup>51, 52</sup>

## Patient Satisfaction

Although effectiveness of medical interventions has traditionally been measured using complication and mortality rates, patient experience is increasingly considered a vital part of the quality framework.<sup>8, 53</sup> Public and private payers have also begun to recognize patient experience as a core element of quality and are adjusting reimbursement accordingly.<sup>8</sup>

As with patient preferences for other minimally invasive procedures, EVH has been associated with significantly less pain and greater patient satisfaction than traditional open vein harvest procedures.<sup>44</sup>

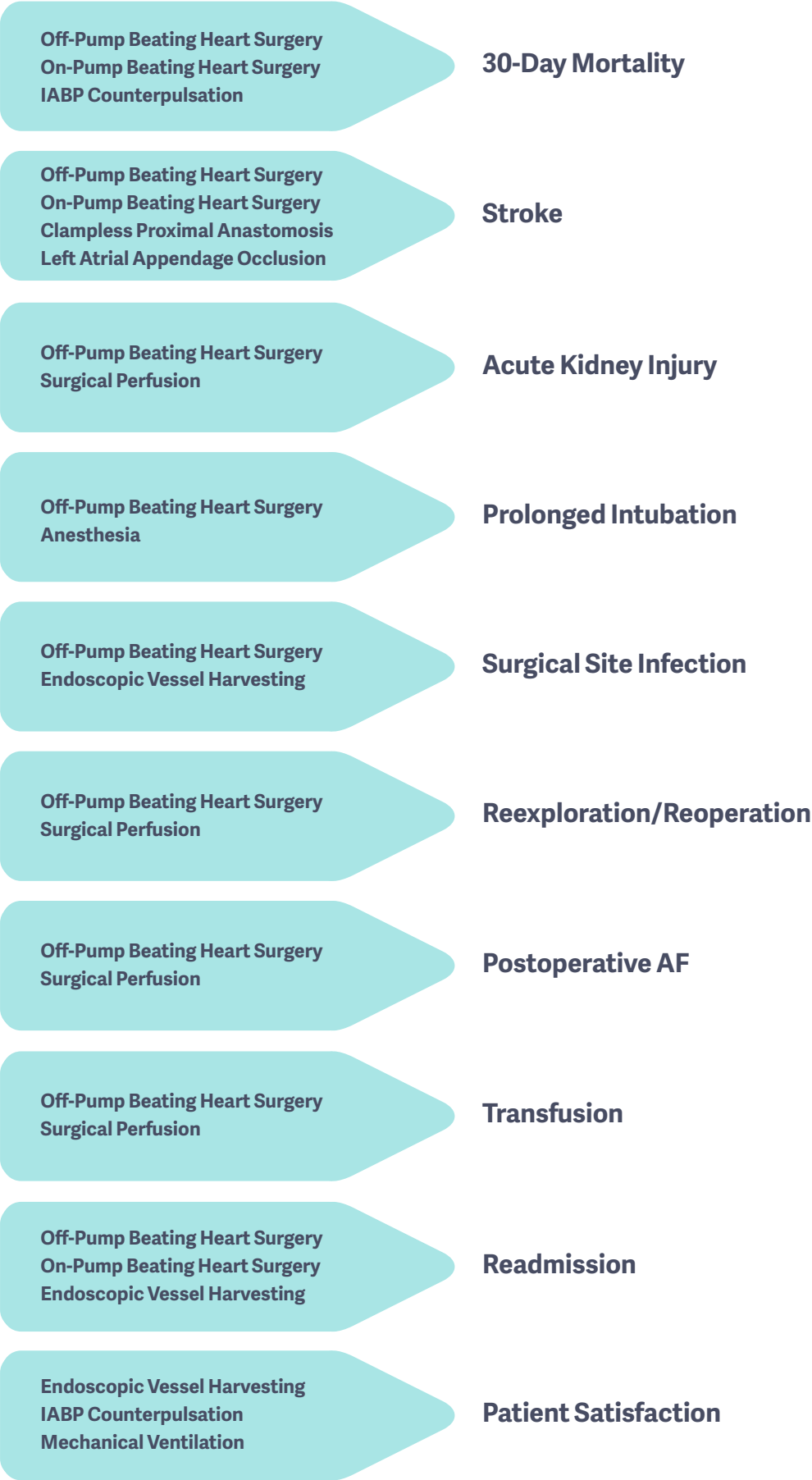
Refractory angina is experienced by an increasing number of patients with coronary artery disease who have already undergone multiple PCIs or previous surgical revascularization and are not candidates for additional procedures. Substantial reduction in the frequency and intensity of angina pain has been reported with use of IABP counterpulsation in this patient group.<sup>54</sup>

Personal ventilation utilizing neurally adjusted ventilatory assist (NAVA) has been shown to improve patient-ventilator synchrony.<sup>55</sup> NAVA delivers assist in proportion to and in synchrony with the patient's respiratory efforts, which can contribute to fewer periods of over- and under-assist,<sup>56, 57</sup> improved patient comfort,<sup>58</sup> and improved sleep quality.<sup>59</sup>

## **Summary and Conclusions**

Improving CABG quality has important implications not only for superior clinical outcomes but for hospital reimbursement, patient satisfaction and cardiac surgery provider reputation. Reducing postoperative complications that compromise revascularization results, prolong recovery and increase readmissions and healthcare costs is essential to meeting both patient and payer demands for quality. Utilizing advanced technologies and evidence-based best practices will allow cardiac surgeons to deliver highest-quality coronary revascularization to patients with increasingly challenging risk profiles.

**Figure 2. Impact of Therapies on CABG Quality Outcomes**



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