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Review Article

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# Long-term outcomes of CABG with intra-aortic balloon pump support

**Abstract**
Analyzed literature data concerning late outcomes of CABG with intra-aortic balloon pump (IABP) support in high-risk patients with acute coronary syndrome. MEDLINE, EMBASE, Scopus, The Benchmark Counterpulsation Outcomes Registry, Cochrane registry of Controlled Trials, and reference lists of relevant articles were searched. Results of surgery were matched with: 1).suitable option and time of surgery; 2).initial risk profile of patients; 3).tactic strategy, and timing of IABP connection; 4).leading risk predictors of in-hospital, and late results of surgery.

**Keywords:** Acute myocardial infarction, CABG; intra-aortic balloon pump, low cardiac output syndrome, hospital and late outcomes

## INTRODUCTION

Unlike the vast majority reference publications of in-hospital (1-16) and short-term (2-6 months) outcomes of CABG with IABP support (17,18), the long-term outcomes (mainly up to 15 years) are limited to as few as 9 series, which are mostly presented by analysis of the either long-term survival, or mortality. The analysis was conducted without differentiation between isolated and combined CABG with correction of MI (myocardial infarction) mechanical complications/valvular prosthesis; elective/urgent surgery (18-23). The long-term outcomes in isolated on-pump/off-pump CABG were analyzed in three series (1,4,20); the outcomes of isolated and combined CABG – in 6 series (6,7,10,11,18,19).

The analysis of long-term outcomes of CABG with IABP is complicated due to heterogeneity of the publications, which can be presented as follows: **1).** The surgery outcomes either before (20,21), or after 2000 (18,19,22-26), or consolidated results in patients underwent surgery before and after 2000 (25); **2).** Consolidated outcomes in patients underwent CABG with IABP and off-pump surgery (23,26); **3).** Consolidated outcomes in patients underwent isolated or combined CABG (elective/urgent), including isolated valve prosthesis (18-23); **4)**. Long-term outcomes in patients ≤70 and >70 age, with different hemodynamic status; the surgery in patients with acute myocardial infarction/unstable angina; different LVEF values, varying between ≤30-50%; existence/absence of mechanical MI complications; chronic kidney failure/admitted to hemodialysis, or indicated after surgery; **5).** Heterogenous long-term outcomes with preventive IABP in patients with initially stable hemodynamics (18-26).

### The purpose of review

The analysis of long-term outcomes of the isolated and combined CABG with IABP in high and very high-risk patients with acute coronary syndrome.

The analysis of long-term outcomes of the CABG with IABP is complicated due to heterogeneity of the publications, which

are presented as follows: 1). Surgery outcomes either before (6,7) or after 2000 (1,10,11,18-20); **2).** Consolidated analysis of outcomes patients underwent surgery before and after 2000 (4); **3).** Consolidated long-term outcomes of on- and off-pump CABG (4,20); **4).** The analysis of long-term surgery outcomes without differentiation of isolated and combined CABG, performed in different hemodynamic status. Bearing in mind abovementioned, during the analysis of publications on long-term outcomes of CABG with IABP we were considering the patients' initial risk profile, the mode of intervention, mode of IABP and short-term surgery outcomes, concerning the IABP as non-direct predictor of long-term outcomes.

The long-term outcomes of surgery before 2000. are clearly demonstrated by OE. Arafa et al. (1998) (6) and KS. Naunheim et al. (1992) (7), the authors were analyzing 163 and 202 survived patients on follow-up up to 15.3 and 9 years after operations performed in 1980-1989. and 1983-1990., respectively. In both series CABG was performed in 62.8% and 64.8% cases, respectively; the urgent operations – 35% and 51%, respectively; combined CABG and isolated valvular interventions – 37.2 and 35.2%, respectively.

In comparison with early mortality 52.6 and 44%, respectively, the actual survival rate during to 1;3;5 and 9 years of follow-up was 40-51%; 47%; 32.3-42%; 22-32%, respectively. The worst long-term outcomes were in surgery patients with initial high creatinine level and IABP in operational room and ICU, whereas the patients with IABP before surgery had better results. The long-term survival of surgery patients with chronic kidney failure in 1-5-9 years follow-up was respectively 17.1%; 14.6% and 9.8%; 10 years survival rate of the patients with IABP before surgery /in operation room/ in ICU was 45.1%, 20.8% and 20.3%, respectively (6). We consider that the relatively worse long-term surgery outcomes in OE. Arafa. et al series than in KS. Naunheim ones were due to prevailing number of patients in III-IV NYHA Class (2,1:1), respectively 92.7% and 43.8%; greater rate of AMI in PMH (past medical history) (2:1), respectively 64.5% and 32%; prevailing number of isolated operations on valves (1.9:1), respectively 19.5% and 10.4%. Along with early mortality rate 44% K.S. Naunheim et al detected clinical improving as I-II NYHA Class in 81% of patients during long-term follow-up (7). The predictors of long-term mortality were defined during regression analysis as IABP timing ($p<0.01$), initial creatinine level ($p<0.05$) and duration of cardiopulmonary by-pass ($p<0.05$). The age factor was defined as borderline predictor of long-term mortality ($p<0.06$) (6).

Despite of high-risk profile of the patients, rate of urgent and combined operations, the long-term outcomes of surgery with IABP were relatively improved by 2000-2019 (1,4,10,11,18-20). Urgent CABG in patients with acute MI and/or cardiogenic shock were performed in 12.3-67% cases on long-term follow-up (10,11,18-20), and have been conducted 100% of cases in E. Hemo et al. series (2014) (4). The combined operations were performed in 11.9-16.2% cases (10,11,18,19). In-hospital mortality in long-term series after 2000 was varying between 0% and 47.6% (mean 21,9%) (1,4,10,11,18-20), respectively 0% and 1.2% in K. Nakamura et al. (2019) (20) and R. Larusso et al. (2010) (10).

Long-term survival up to 3-5 years of follow-up after isolated CABG with IABP was 97 and 100% (1,20); 10-years survival - 48.7±3.5% (4). Consolidated survival up to 3 and 5 years after isolated and combined CABG was 72.7% and 79.2% (18,19), the better outcomes were detected in R. Lorusso et al. (2010) series (10), which were 91.7±3.1% and 84.3±5.5% in 5 and 8 years of follow-up, respectively; relatively worse outcomes on long-term survival in H. Kamiya et al. (2016) (11) series were 56.6% and 46.8% in 1 and 5 years of follow-up, respectively.

The analysis showed that the long-term outcomes of CABG with IABP are more depending on the initial risk profile, mode of operations, the timing and mode of IABP, rather than early mortality rate. This correlation was clearly demonstrated during long-term follow-up to 180 months (8±4 years) by E. Hemo et al. (2014) series (4) in 188 patients underwent isolated CABG with preventive IABP in 1996-2000, including 24.6% of the off-pump surgeries. All patients were operated ≤24 hours of hospitalization. The 30-day mortality was 12.6% (expected mortality was 32.8%), 10-year actual survival was 48.7±3.5% with better survival with both IMAs approach, rather than in one IMA mode, respectively 62.6±5.3% and 39,5±4.4% ($p<0.001$), the analysis was conducted without confidence verification during multifactorial regression analysis. The worse outcomes of long-term survival were detected in patients with cardiogenic shock, rather than in unstable hemodynamics, respectively 35.3±11.6% and 56.6±8.2% ($p<0,049$); in women and in men, respectively (31.7±6% и 58,3±6%) ($p<0,001$); in patients with peripheral vascular disease, rather than without it, (21.4±6.3% и 58.8±6.8%) ($p<0.001$); in off-pump CABG rather than in on-pump mode (23.6±6% and 67.4±7.2%, respectively) ($p<0.001$).

The presented parameters of long-term mortality are depending on the following issues: consolidated analysis of long-term outcomes of on-pump and off-pump CABG during 1996-2001; performing of the surgeries in patients with initial clinical instability, cardiogenic shock, and acute MI in 39.1%; 8.4% and 17.7%, respectively; operated in patients with MI <1 week and MI > 30 days, respectively 48,8% and 28,4%; lesion of left main coronary in 55.8% (4).

We selected mostly large mixed cohort series during analysis of long-term outcomes of CABG with IABP (10,11,18,19) (10,11), reflecting best (10) and unsatisfactory long-term outcomes (11), which were mainly depending on patients' risk profile, mode of operation and IABP mode, rather than early mortality rates.

In H. Kamiya et al. Series (2016) (11), analysis of surgery outcomes of 522 patients with IABP, 30-day mortality was 30.8%, which was identical to mortality rate in IABP in operation room and ICU, respectively 31.1% and 28.2%; 6-month mortality was

40%. Survival rate on 1- and 5-year follow-up was respectively 56.6% and 46.8%. The worse outcomes were due to the following: **1).** High risk profile of the patients, out of which 56% were operated in NYHA Class IV; 31.9% and 2.7% - respectively, in patients with chronic kidney failure and hemodialysis; **2).** Urgent operations, combined CABG, and isolated interventions on valves, respectively 67%, 21.4% and 12.5%; heart transplantation in 4% cases; **3)**. Post-op hemodialysis in 31.7% of patients; **4)**. Exclusion from analysis 14.9% of patients, underwent surgery with IABP before operation and 24 hours after operation.

In R. Larusso et al. series (2010) (10), in-hospital mortality in surgery with preventive IABP (n=478) and without IABP (n=478) was 1.2% and 3.7% ($p<0.001$); 30-day mortality - 2.5% and 5.34% ($p<0.001$).

Initial risk profile of the patients was presented with cardiogenic shock in 21.3% of cases; AMI in <15 days and >15 days – in 15.6% and 7.5%, respectively; LVEF ≤35% and left main coronary artery lesion in 12.1% and 6.9%, respectively; chronic kidney failure and hemodialysis in 37.4% and 2.5% patients.

Despite of high-risk profile and 43.3% isolated operations on valves, the long-term outcomes in R. Larusso et al. (2010) (10) were significantly different from the of data of H. Kamiya et al. (2016) (11). The long-term survival after operations with preventive IABP and without it, was as follows: up to 5 years follow-up 91.7±3.1% and 95±2.1%, respectively ($p=0.34$); up to 8 years - 84.3±5.5% and 85.9±6.1%, respectively ($p=0.2$). The further improvement in LVEF ($p<0.001$) and decrease in dimensions of the left ventricle ($p<0.001$) (10).

The better long-term outcomes in R. Larusso et al. (2010) series than in H. Kamiya et al. (2016) series are explained: **1).** Preventive use of IABP; **2).** Fivefold less ratio of urgent CABG (1:5,4), respectively 12.3% and 67%; **3).** Less volume (1:1.8) of combined CABG, respectively 11.9% and 21.4%.

The acceptable long-term survival and mortality after CABG with IABP in patients underwent surgery after 2000 are characterized by relatively less stability of good long-term outcomes. Notwithstanding relatively low mortality (0% and 3%) during 38.55±22.7 and 42.5±42.6 months of follow-up after isolated CABG with IABP (1,20), there were no significant difference in long-term survival and outcomes stability parameters between patients operated with preventive IABP and without it, the long-term outcome stability was identical up to 12 months in follow-up of both groups, i.e., 69% (20) (рис2). The similar non-significant difference of the long-term survival was observed in patients operated with preventive IABP and without it, R. Larusso et al. (2010) (10).

The consolidated stability parameters of good long-term outcomes of isolated and combined CABG up to 36 months were 45.5% (19).

## CONCLUSION

The long-term outcomes of CABG with IABP are depending on the initial risk profile of the patients, surgery mode and timing, IABP mode and timing concerning unstable hemodynamics. IABP itself has certain influence on early outcomes of CABG with IABP and, therefore, should be considered as non-direct predictor of long-term surgery outcomes.

**Conflict of Interests:** The author declares that there are no conflict of interests.

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**Data Availability Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

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