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# Total arterial myocardial revascularization in patients over 70 years old - a new trend in coronary surgery in elderly

## Całkowita tętnicza rewaskularyzacja u chorych po 70 r. ż. - nowy trend w chirurgii wieńcowej u starszych pacjentów

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**Additional key words:**
total arterial revascularization
short-term outcome
elderly patients

**Dodatkowe słowa kluczowe:**
całkowita tętnicza rewaskularyzacja
wczesne wyniki okołooperacyjne
starsi pacjenci

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**Introduction: In modern society, civilization has extended the life expectancy of developed nations. The demographic analysis of Eurostat (European Statistical Office) predicts the increase of the population over 70 years old in Western Europe from 15.2% reported in 1995 to 19.5% in 2020. Undoubtedly, the incidence of cardiovascular diseases increases with age. Nowadays, they are the most commonly diagnosed disease, as well as the most common cause of death in patients over 70 years old. Therefore, a significant increase of surgeries in elderly patients, reaching up to 30%, is reported in cardiac surgery. As changes in operating technique are being observed, better outcomes of surgeries in elderly patients are being noted. With over 10 years of observation, more beneficial results are noted for arterial revascularization with usage of arterial grafts compared with venous ones. The aim of the study is to evaluate the safety of harvesting both internal mammary arteries and radial artery in CABG in patients over 70 years old and to analyze the incidence of major adverse cardiac and cerebrovascular events (MACCE) and other postoperative complications in this cohort.**

**Material and Methods: In a retrospective observational study we analyzed 101 cases, where TAMR was applied in patients aged 70 yo or older between 2003 to 2009 in the Department of Cardiovascular Surgery and Transplantology, John Paul II Hospital, Kraków. Exclusion criteria included among others low left ventricular ejection fraction, high Euroscore, and accompanying valvular disease. Data was obtained from patient medical records.**

**Baseline characteristics, intraoperative data and postoperative complications were assessed.**

**All surgeries were performed in extracorporeal circulation and via median sternotomy.**

**Results: In the study cohort, most**

**Wstęp: Obecnie rozwój cywilizacyjny wydłuża oczekiwaną długość życia w krajach rozwiniętych. Analiza demograficzna danych z Eurostat przewiduje wzrost populacji osób po 70 r. ż we Wschodniej Europie z 15,2%, raportowanych w 1995 r., do 19,5% w roku 2020. Niewątpliwie zapadalność na schorzenia układu krążenia wzrasta z wiekiem. Obecnie są to najczęściej diagnozowane choroby jak i najczęstsza przyczyna zgonów wśród pacjentów po 70 r.ż. Z tego powodu obserwowany jest również znaczny wzrost zabiegów chirurgicznej rewaskularyzacji w tej grupie chorych, sięgający 30% wszystkich wykonywanych procedur pomostowania aortalno-wieńcowego. Obserwując zmiany w technikach operacyjnych, obserwowane są również coraz lepsze wyniki tych procedur w starszych grupach wiekowych. Faktem jest również, iż coraz lepsze wyniki, zwłaszcza w odległej obserwacji, są raportowane w przypadku zastosowania rewaskularyzacji z użyciem pomostów tętniczych w porównaniu do pomostów żylnych. Praca ma na celu przedstawienie wczesnych wyników okołooperacyjnych pomostowania aortalno-wieńcowego w grupie chorych po 70 r.ż. Z użyciem wyłącznie tętniczych pomostów.**

**Materiał i metodyka: W retrospektywnej analizie oceniono wczesne wyniki pooperacyjne 101 chorych po 70 r. ż., poddanych całkowitej tętniczej rewaskularyzacji, którzy operowani byli w Klinice Chirurgii Serca, Naczyń i Transplantologii, KSS im. Jana Pawła II w Krakowie w latach 2003 - 2009. Kryterium wykluczenia stanowiły m.in. niska frakcja wyrzutowa, wysoki wynik Euroscore, towarzysząca wada zastawkowa. Dane zostały uzyskane z dostępnej dokumentacji medycznej. Zebrana została przedoperacyjna charakterystyka pacjentów, dane śródoperacyjne oraz dane dotyczące przebiegu pooperacyjnego. Wszystkie zabiegi wykonane zostały w krążeniu pozaustrojowym z dostępu przez sternotomię.**

**Wyniki: W badanej grupie u więk-**

**patients suffered from multi-vessel disease (65.3%), and all required at least 2 bypass grafts. Left internal mammary artery (LIMA) was used in all cases, right internal mammary artery (RIMA) in 30.7%, and radial artery (RA) in 95% of surgeries. In 6.9% of individuals additional transmyocardial laser revascularization was applied due to disseminated coronary artery disease. The in-hospital mortality stood at 1.98%, however there were no cardiac deaths reported. The postoperative MACCE incidence was 6.94% due to 6 cases of myocardial infarction, and 1 case of acute stroke. The in-hospital mortality was 1.98%. Other postoperative complications occurred as follows: rethoracotomy (2.9%), blood products transfusions (69.3%), prolonged mechanical ventilation (9.9%), atrial fibrillation (15.8%), deep wound infection (3.96%), sternal dehiscence (1.98%).**

**Conclusions: Technique of TAMR in coronary artery bypass grafting is a safe method in low-risk patients over 70 years old and can be performed with good short-term outcome. Further evaluation analyzing the long-term benefits in elderly patients of TAMR is warranted.**

**szości pacjentów stwierdzono trójnaczyniową chorobę wieńcową (65,3%). Pacjenci wymagali przynajmniej dwóch zespoleń. Lewa tętnica piersiowa wewnętrzna użyta była we wszystkich przypadkach, prawa tętnica piersiowa wewnętrzna w 30,7% przypadków, a tętnica promieniowa w 95%. W 6,9% procedur dodatkowo wykonano Laserową Rewaskularyzację z uwagi na rozległe zmiany miażdżycowe.**

**Pooperacyjne niepożądane zdarzenia sercowe oraz mózgowo-naczyniowe (MACCE) wystąpiły u 6,94% pacjentów, a śmiertelność okołooperacyjna wynosiła 1,98%. Pozostałe powikłania wystąpiły z następującą częstością: retorakotomia (2,9%), przetoczenie masy czerwonokrwinkowej (69,3%), przedłużona mechaniczna wentylacja (9,9%), migotanie przedsionków (15,8%), infekcja mostka (3,96%), resutura mostka (1,98%).**

**Wnioski: Technika całkowitej tętniczej rewaskularyzacji jest bezpieczną metodą u pacjentów niskiego ryzyka po 70 r. ż. i może być wykonywana z uzyskaniem dobrych wyników okołooperacyjnych. Konieczna jest dalsza analiza oceniająca odległe wyniki i potencjalną korzyść z zastosowania pomostów tętniczych w tej grupie wiekowej.**

## Introduction

In modern society, civilization has extended the life expectancy of developed nations. The demographic analysis of Eurostat (European Statistical Office) predicts the increase of the population over 70 years old (yo) in Western Europe from 15.2% reported in 1995 to 19.5% in 2020 [1]. Demographic changes are also observed in Polish society and according to statistical yearbook 1996, individuals over 65 yo consisted 11.4% of the population and it is predicted that this percentage will increase up to 24% in the year 2020 [2]. Undoubtedly, the incidence of cardiovascular diseases increases with age. Nowadays, they are the most commonly diagnosed disease, as well as the most common cause of death in patients over 70 yo. Cardiovascular Health Study reported that determinants of subclinical coronary artery disease were present in 22% females and 33% males aged 65-70 yo and in 43% females and 45% males aged ≥ 75 yo [3,4].

Therefore, a significant increase of coronary artery bypass grafting (CABG) in elderly patients, reaching up to 30%, is reported. However, older age is also an independent risk factor for postoperative complications in cardiac surgery and is associated with higher hospitalization costs, due to high incidence of postoperative complications [5-7]. It is therefore crucial to establish a safe technique with satisfactory long-term outcome in this challenging cohort of patients.

Within over 10 years of observation, more beneficial results are noted for arterial revascularization with usage of arterial grafts compared with venous ones. It has been well documented that in long-term follow up, arterial grafts remain superior patency over venous [8,9], however no evaluations of total arterial revascularization (TAMR) in elderly patients have been reported.

The aim of the study is to evaluate the safety of harvesting both internal mammary arteries and radial artery in CABG in patients over 70 years old and to analyze the incidence of major adverse cardiac and cerebrovascular events (MACCE) and other postoperative complications in this cohort.

## Material and methods

In a retrospective observational study we analyzed 101 cases, where TAMR was applied in patients aged 70 yo or older between 2003 to 2009 in the Department of Cardiovascular Surgery and Transplantology, John Paul II Hospital, Kraków. Data was obtained from patient medical records.

Exclusion criteria were as follows:

- single vessel disease
- recent myocardial infarction (MI) with unstable hemodynamic status
- disseminated atherosclerosis of the ascending aorta
- accompanying valvular disease
- high Euroscore (>10)
- left ventricular ejection fraction (LVEF) ≤30%

Most of the operated patients were males (62.4%), and the mean age in the study cohort was 74 yo. Nearly all of the individuals had at least two diseased vessels (97%) and suffered from hypertension (96%). Also other comorbidities were observed with high incidence, i.e. hyperlipidemia (68.3%), diabetes (34.8%), peripheral artery disease (PAD) (30.6%), chronic obstructive pulmonary disease (COPD) (10.8%)(Tab. I).

All surgeries were performed in extracorporeal circulation via median sternotomy.

Postoperative complications were assessed as follows:

- MACCE, defined as any postoperative MI, death from cardiac causes and acute stroke
- Low cardiac output syndrome (LCOS) without elevated cardiac enzymes
- Death from non-cardiac causes
- Prolonged mechanical ventilation (>72 hours)
- Sternal dehiscence
- Deep wound infection
- Excessive bleeding requiring rethoracotomy
- Need for Packed Red Blood Cells (PRBC) transfusions
- Newly diagnosed atrial fibrillation (AF)

## Results

Most of the individuals were operated electively (87.1%) and required at least 2 bypass grafts. Left internal mammary artery (LIMA) was used in all cases. The right internal mammary artery (RIMA) was used in 30.7%, while the radial artery (RA) in 95% of surgeries. In 6.9% of individuals, additional transmyocardial laser revascularization was applied due to disseminated coronary artery disease (Tab. II).

The in-hospital mortality stood at 1.98%, however there were no cardiac deaths reported. The postoperative MACCE incidence valued 6.94%, due to 6 cases of postoperative MI and 1 acute stroke. Other postoperative complications occurred as follows: LCOS (6.93%), prolonged mechanical ventilation (9.9%), sternal dehiscence (1.98%), deep wound infection (3.96%), rethoracotomy (2.9%), PRBC transfusions (69.3%), and newly diagnosed AF (15.8%) (Tab. III).

## Discussion

Age is a significant risk factor for poor outcome after cardiac procedures and is included in all risk stratification scores. Furthermore, comorbidities in elderly patients are described to be associated with negative outcomes [5,10]. However, in-hospital mortality observed in the study cohort was acceptable and was found to be lower than the mortality rate observed for septuagenarians in another study (1.98% vs 7.1% in females, and 4.7% in males) [11]. This difference may be caused by the fact that the cohort of our study comprised mostly of low-risk patients with preserved left ventricular function and therefore, no conclusions regarding the beneficial influence of TAMR in this age group can be established. Nevertheless, the observed mortality was similar to all elective isolated CABG procedures performed at our Institution between 2006-2012 and is acceptable in this selected subgroup.

Currently, implantation of one arterial and one or more venous grafts is a standard approach in coronary surgery. Usually LIMA graft is implanted to LAD and venous grafts to other diseased vessels. When LIMA grafts were first introduced in 1985, the mortality rate for elderly patients stood at 9.3% and has fallen since then to 5.5%. Major surgical

**Table I**
**Baseline characteristics.**
Przedoperacyjna charakterystyka grupy.

| Variables | Analyzed population, n=101 |
|---|---|
| Age, years | 73.97 (±2.84) |
| Male sex, n (%) | 63 (62.4) |
| BMI, kg/m$^2$ | 28.2 (±4.21) |
| Diabetes, n (%) | 35 (34.6) |
| Hypertension, n (%) | 97 (96) |
| Hyperlipidemia, n (%) | 69 (68.3) |
| CKD, n (%) | 10 (9.9) |
| PAD, n (%) | 31 (30.6) |
| COPD, n (%) | 11 (10.8) |
| Two-vessel disease, n (%) | 32 (31.7) |
| Three-vessel disease, n (%) | 66 (65.3) |
| Varicose veins, n (%) | 48 (47.2) |
| Previous stroke, n (%) | 8 (7.9) |
| Previous MI, n (%) | 68 (67.3) |

**Data shown as mean ± SD or number (percentage). Abbreviations: BMI - body mass index; CKD - chronic kidney disease; PAD - peripheral artery disease; COPD - chronic obstructive pulmonary disease; MI - myocardial infarction**

**Table II**
**Intraoperative data.**
Dane śródoperacyjne.

| Variables | Analyzed population, n=101 |
|---|---|
| Elective surgery, n (%) | 88 (87.1) |
| Aortic Cross-Clamp time, minutes | 30 (±8.4) |
| Extracorporeal Circulation time, minutes | 54.4 (±17.4) |
| 2 bypass grafts, n (%) | 53 (52.5) |
| 3 bypass grafts, n (%) | 46 (45.6) |
| 4 bypass grafts, n (%) | 2 (1.9) |
| LIMA graft, n (%) | 101 (100) |
| RIMA graft, n (%) | 31 (30.7) |
| RA graft, n (%) | 96 (95) |
| TMLR, n (%) | 7 (6.9) |

**Data shown as mean ± SD or number (percentage). Abbreviations: LIMA - left internal mammary artery; RIMA - right internal mammary artery; RA - radial artery; TMLR - transmyocardial laser revascularization**

**Table III**
**Postoperative complications.**
Powikłania pooperacyjne.

| Variables | Analyzed population, n=101 |
|---|---|
| Cardiac death, n (%) | 0 (0) |
| MI, n (%) | 6 (5.94) |
| Acute stroke, n (%) | 1 (0.98) |
| LCOS, n (%) | 7 (6.93) |
| Death from non-cardiac causes, n (%) | 2 (1.98) |
| Prolonged mechanical ventilation, n (%) | 10 (9.9) |
| Sternal dehiscence, n (%) | 2 (1.98) |
| Deep wound infection, n (%) | 4 (3.96) |
| Rethoracotomy, n (%) | 3 (2.9) |
| PRBC transfusions, n (%) | 70 (69.3) |
| AF, n (%) | 16 (15.8) |

**Data shown as number (percentage). Abbreviations: MI - myocardial infarction; LCOS - low cardiac output syndrome; PRBC - packed red blood cells; AF - atrial fibrillation**

complications have been either reduced or unchanged in patients receiving LIMA grafts [12].

Moreover, arterial grafts show better long term patency over venous. Bypass angiography in a 1 year follow-up showed significant occlusions in 25% of venous vs 8% of LIMA grafts [13,14]. Because of high LIMA graft patency (over 80% 10-15 yrs post-surgery), other arterial grafts were studied and RIMA was introduced in the coronary surgery with satisfactory long-term patency (96% 5, and 81% 10 yrs post-surgery) [15,16]. RIMA graft may be implanted either to right or left coronary artery with low perioperative mortality and good 5 yrs follow-up [8]. Also RA is nowadays more commonly used in surgical revascularization. RA was first used in 1971 and then later abandoned due to scientific reports of 60% rate occlusion. Further analysis, however, indicated that low patency was a result of arterial spasm rather than inadequate graft material choice. Favorable results of RA implantation have been proved by a randomized multi-centre study, which showed 91.8% patency vs 86.4% observed for venous grafts [17]. Moreover, RA can be harvested simultaneously with LIMA, which decreases the procedure time compared to the procedure with both internal mammary artery implantation.

Despite the beneficial long-term outcome, arterial grafts are not commonly used for all patients, especially elderly. Relative contraindications that presumably indicates standard grafts implantation include left ventricular hypertrophy, severe left ventricular dysfunction, emergency operations, COPD with enlarged lungs, advanced age, and an obstructed left subclavian artery [12,18].

Nevertheless, indications for arterial grafts include:

• varicose veins and lack of venous material,
• familial hypercholesterolemia,
• diabetes,
• chronic kidney disease (CKD),
• small diameter of coronary arteries,
• reoperation due to closed venous grafts,
• disseminated atherosclerosis of ascending aorta,
• Kawasaki disease.

In the study cohort, nearly 10% of individuals required prolonged mechanical ventilation. This results from the need of opening both pleuras and, as a consequence, greater surgical injury. However, the incidence of sternal dehiscence and deep wound infections was satisfactory considering patients' age and comorbidities.

## Conclusions

Technique of TAMR in coronary artery bypass grafting is a safe method in low-risk patients over 70 years old and can be performed with good short-term outcome. Further evaluation analyzing the long-term benefits in elderly patients of TAMR is warranted.

**References:**


1. **Peka KK**: Demografia. Świat się starzeje. Rzeczpospolita. 9.04.2002; A7.
2. **Wóycicka I, Chłoń-Domińczak A**: Strategia polityki społecznej 1999-2020. Instytut Badań nad Gospodarką Rynkową, Warszawa 1999; 15-24.
3. **Kuller L, Fisher L, McClelland R, Fried L, Cushman M. et al**: Differences in prevalence of and risk factors for subclinical vascular disease among black and white participants in the cardiovascular health study. Arterioscler Thromb Vasc Biol. 1998; 18: 283-293.
4. **Kuller L, Borthani N, Psaty B, Furberg C, Gardin J. et al**: Prevalence of subclinical atherosclerosis and cardiovascular disease and association with risk factors In the Cardiovascular Health Study. Am J Epidemiol. 1994; 139: 1164.
5. **Weisel R, Nussmeier N, Newman M, Pearl R, Wechsler A. et al**: Predictors of contemporary coronary artery bypass grafting outcomes. J Thorac Cardiovasc Surg. 2014; 148: 2720-6.e1-2.
6. **Mortasawi A, Arnrich B, Walter J, Frerichs I, Rosendahl U, Ennker J**: Impact of age on the results of coronary artery bypass grafting. Asian Cardiovasc Thorac Ann. 2004; 12: 324-329.
7. **Eisenberg M, Chee J, Filion K, Haider S, Pilote L**: Impact of age on hospital course and cost of coronary artery bypass grafting. Am J Cardiol. 2004; 93: 768-771.
8. **Barner HB, Standeven JW, Reese J**: Twelve-year experience with internal mammary artery for coronary artery bypass. J Thorac Cardiovasc Surg. 1985; 90: 668-675.
9. **Calafiore A, Di Giammarco G, Luciani N, Maddestra N, Di Nardo E, Angelini R**: Composite arteria conduits arterial for a wider arterial mycordial revascularsization. Ann Thorac Surg. 1994; 58: 185-190.
10. **Higgins T, Estafanous F, Blum J, Loop F, Beck G, Paranandi L**: Stratification of morbidity and mortality outcome by preoperative risk factors in coronary artery bypass patients. A clinical severity score. JAMA. 1992; 267: 2344.
11. **Arif R, Farag M, Gertner V, Szabó G, Weymann A. et al**: Female gender and differences in outcome after isolated coronary artery bypass graft surgery: Does age play a role? PLoS One. 2016; 11:e0145371.
12. **Gardner T, Greene P, Rykiel M, Baumgartner W, Cameron D. et al**: Routine use of the left internal mammary artery graft in the elderly. Ann Thorac Surg. 1990; 49: 188-193.
13. **Magee M, Alexander J, Hafley G, Ferguson J, Gibson C. et al**: Coronary artery bypass graft failure after on-pump and off-pump coronary artery bypass: findings from PREVENT IV. Ann Thorac Surg. 2008; 85: 494-499.
14. **Nakayama Y, Sakata R, Ura M, Miyamoto T**: Coronary artery bypass grafting in dialysis patients. Ann Thorac Surg. 1999; 68: 1257-1261.
15. **Gurevitch J, Paz Y, Shapira I, Matsa M, Kramer A. et al**: Routine use of bilateral skeletonized internal mammary arteries for myocardial revascularization. Ann Thorac Surg. 1999; 68: 406-411.
16. **Samuels LE, Sharma S, Kaufman MS, Morris RJ, Brockman SK**: Coronary artery bypass grafting in patients in their third decade of life. J Card Surg. 1996; 11: 402-407.
17. **Deb S, Cohen E, Singh S, Une D, Laupacis A, Fremes S**: Radial artery and saphenous vein patency more than 5 years after coronary artery bypass surgery. Results from RAPS (Radial Artery Patency Study). J Am Coll Cardiol. 2012; 60: 28-35.
18. **Leavitt B, O'Connor G, Olmstead E, Morton J, Maloney C. et al**: Use of the internal mammary artery graft and in-hospital mortality and other adverse outcomes associated with coronary artery bypass surgery. Circulation 2001; 103: 507-512.