

## Risk factors of increased chest tube drainage in patients undergoing off-pump coronary artery bypass surgery

Czynniki ryzyka zwiększonego drenażu klatki piersiowej  
u pacjentów poddawanych operacji pomostowania aortalno-wieńcowego  
bez użycia krążenia pozaustrojowego

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Doktor nauk medycznych Wojciech Szycha jest absolwentem Wydziału Lekarskiego Uniwersytetu Medycznego w Łodzi (2008 r.). Jego rozprawa doktorska (promotor: prof. dr hab. n. med. Krzysztof J. Filipiak, promotor pomocniczy: dr n. med. Franciszek Majstrak) dotyczyła zmiany charakterystyki pacjentów kierowanych na kardiochirurgiczną rewaskularyzację wieńcową i rodzajów farmakoterapii stosowanej przy wypisaniu ze szpitala. Doktor Szycha, obecnie w trakcie specjalizacji z kardiologii, jest autorem lub współautorem 13 artykułów, z łącznym dorobkiem naukowym IF 4,516 punktu. W kręgu jego zainteresowań medycznych pozostaje śródoperacyjna ocena echokardiograficzna, a szczególnie ocena echokardiograficzna w naprawach zastawki mitralnej i aortalnej. Pracuje w I Katedrze i Klinice Kardiologii Warszawskiego Uniwersytetu Medycznego (WUM) (kierownik: prof. dr hab. n. med. Grzegorz Opolski) – jednym z wiodących akademickich ośrodków kardiologicznych w Polsce. W strukturze Katedry jest Klinika Kardiologii WUM, co umożliwia prowadzenie wysokospecjalistycznego leczenia. W wolnym czasie dr Szycha biega i jeździ konno.

### Abstract

**Introduction.** The aim of the study is to identify risk factors of increased postoperative bleeding after off-pump surgical treatment of coronary artery disease (OPCAB).

**Material and methods.** A retrospective study including all patients undergoing OPCAB (2004–2008) at a single-center institution, who were analyzed with statistical methods to find risk factors increasing postoperative bleeding. Statistical significance was determined at the level of  $p < 0.05$ .

**Results.** One thousand two hundred and fifty-three patients aged  $65.5 \pm 9.6$  were enrolled into the study. The average amount of drained blood on the first day after the surgery was  $716.74 \pm 430.12$  mL. Seventy-six patients (6%) underwent surgical re-exploration due to postoperative bleeding. Factors elevating mediastinal drainage on the first day after the surgery included: advanced coronary artery disease, administration of clopidogrel at least 5 days before surgery and arterial grafts. Patients also had a higher mediastinal drainage when grafted: left internal mammary artery (LIMA), LIMA and right internal mammary artery (RIMA) as well as LIMA and left radial artery (LRA) ( $p < 0.001$ ). Factors elevating mediastinal drainage were: lower body mass index (BMI) (according to World Health Organization groups) of operated patients ( $p = 0.023$ ), even lower value of the additive EuroScore ( $p < 0.001$ ) and logistical EuroScore ( $p = 0.001$ ), longer duration of operations ( $p < 0.001$ ) and increasing number of grafts ( $p < 0.001$ ). When analyzed according to deciles of BMI and body surface area, the higher drainage was found, the higher decile of BMI was noted ( $p < 0.0001$ ), but the lower drainage was found, the higher decile of BSA was noted ( $p < 0.0001$ ). Finally, no differences were found between deciles 2 and 3, 3 and 4, 4 and 5, 5 and 6, 6 and 7 and the results were similar to non-indexed values ( $p < 0.001$ ). The overall regression model showed that patients who had greater amounts of blood drained had: lower value of BMI ( $p < 0.001$ ), received clopidogrel more often ( $p < 0.001$ ), grafted bilateral internal mammary arteries (BIMA) ( $p < 0.001$ ) and longer lasting operation ( $p < 0.001$ ).

**Conclusions.** Our results suggest that overweight and obese patients have a significantly lower risk of elevated blood drainage. Lost blood should be probably considered an indexed parameter, however our observation needs further evaluation. Surgeons should pay special attention to patients with diabetes, patients with multivessel disease and those who had BIMA used as grafts.

Key words: chest tube drainage, bleeding, CABG, off-pump

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## Introduction

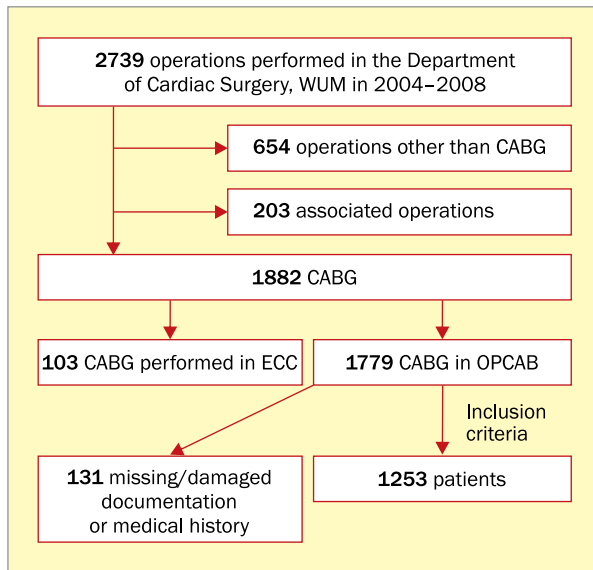
Extensive postoperative bleeding in the first 24-h postoperatively is always a problematic finding. It makes cardiac surgeon to decide if the patient should be reoperated or conservative treatment would be the most appropriate. Patients at high risk of serious complications should be considered for re-sternotomy. Such treatment strategy can be found in 2–12% of patients operated in cardiac surgery departments [1, 2]. However, this complication increases the risk of in-hospital mortality from 2.72 to 22% of reoperated patients [3, 4]. Decision for reoperation should be considered if mediastinal blood drainage exceeds 200 mL/h in the first 4 postoperative hours or when reported bleeding is rapid [2]. Moreover, the mortality is higher if drainage exceeds 2 mL/kg in the first 2 hours or the amount of blood exceeds 200 mL/h in any of the first 6 postoperative hours. Drainage exceeding 495 mL/24 h is also a negative prognostic factor for the need of transfusion, hypotension, organ failure, prolonged ventilation, dialysis, and in-hospital infections [5]. Conservative treatment is also possible and it could be considered shortly after the operation. It is based on administration of the coagulation factors combined with bedside testing (activated clotting time, thromboelastometry, whole blood impedance aggregometry) and results in decreased incidence of blood transfusion and thrombotic/thromboembolic events [6]. Therefore, defining patients with high risk of postoperative hemorrhage is important for postoperative planning.

In this study, we sought to identify patients at high risk of increased postoperative bleeding after off-pump surgical treatment of coronary artery disease (OPCAB).

## Material and methods

This is a retrospective study including all patients who underwent OPCAB in the Department of Cardiac Surgery, Medical University of Warsaw from 01.01.2004 to 31.12.2008. The analysis was conducted on data collected from medical records of patients, following the internal audit approval. The inclusion criteria were: OPCAB through the median sternotomy, one surgeon. The exclusion criteria included: combined procedures (operations different than isolated coronary artery bypass grafting [CABG]) and conversion to surgery with cardiopulmonary bypass (Figure 1).

Parameters were recorded to Microsoft Excel 2007 database from medical documentation. Among them were: age, sex, height, body weight, length of stay in the intensive care unit (ICU) and total length of hospitalization. Occurrence of: arterial hypertension, disorders of carbohydrate metabolism (CMD), chronic kidney disease (CKD), active and past-smoking. Past-smoking was defined as cessation of active tobacco smoking for at least two weeks before the surgery. Additionally, the analysis included co-occurrence of other diseases with negative impact on the outcome, such as: chronic pulmonary diseases (CPD), extracardiac arteriopathy, neurological dysfunction severely affecting day-to-day functional activity (ND), serum



**Figure 1.** Flow-chart showing longitudinal analysis of the study population; WUM (Warszawski Uniwersytet Medyczny) – Medical University of Warsaw; CABG – coronary artery bypass grafting; ECC – extracorporeal circulation; OPCAB – off-pump surgical treatment of coronary artery disease

creatinine concentration more than 2.3 mg/dL preoperatively and previous cardiac surgery requiring opening of the pericardium. Additionally, prevalence of single-, double- and triple-vessel disease, left ventricular ejection fraction (EF), body mass index (BMI), body surface area (BSA), additive and logistic EuroScore, type of coronary artery disease (CAD) (stable/unstable/acute myocardial infarction), mode of operation, duration of the operation, number and type of grafts, were analyzed. Association of chosen common early complications with bleeding and reoperations such as: sudden cardiac arrest, ventricular fibrillation/ventricular tachycardia (VF/VT), asystole/pulseless electrical activity (PEA), stroke, respiratory failure, dialysis, infections, postoperative atrial fibrillation (AF),

intra-aortic balloon pump (IABP) (before, during and after CABG), in-hospital mortality were analyzed. To assess blood loss, such variables as: chest tube drainage within 24-h postoperatively (mL) and amount of transfused packed red blood cells (PRBC) were analyzed. The analysis included also drugs admitted before surgery: clopidogrel up to 5 days preoperatively,  $\beta$ -adrenolytics, angiotensin converting enzyme inhibitors, statins and angiotensin II receptor antagonists.

The data were statistically analyzed for occurrence of increased postoperative bleeding using *t*-test, Kruskal-Wallis test and Rho-Spearman analysis for measurable parameters. For immeasurable parameters was used U Mann-Whitney test. Finally we performed paired comparison analysis for blood drainage indexed with BSA. Statistical significance was determined at the level of *p* below 0.05.

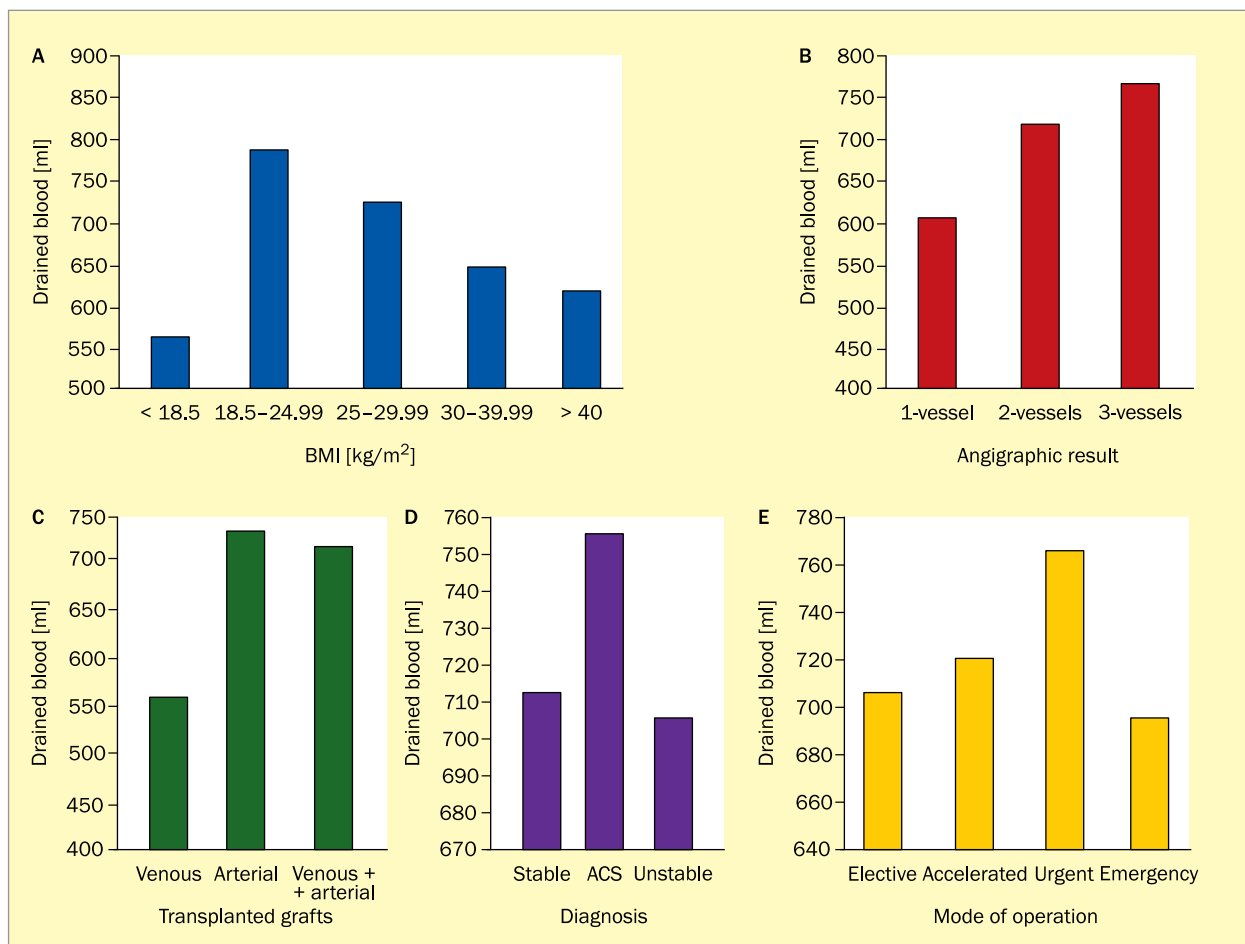
## Results

One thousand and fifty-three patients aged  $65.5 \pm 9.6$  years were enrolled into the study. Nine hundred and twenty-four patients of the analyzed population were male (73.74%). Urgent operation was performed in 131 (10.45%) of cases meanwhile emergency operation was 47 (3.75%) of cases. The average amount of drained blood in the first day after the surgery was  $716.74 \pm 430.12$  mL. Seventy-six patients (6%) underwent a surgical re-exploration due to postoperative bleeding. Patients undergoing reoperation received significantly more PRBC within 24-h postoperatively ( $6.64$  u. vs  $1.98$  u.,  $p < 0.0001$ ).

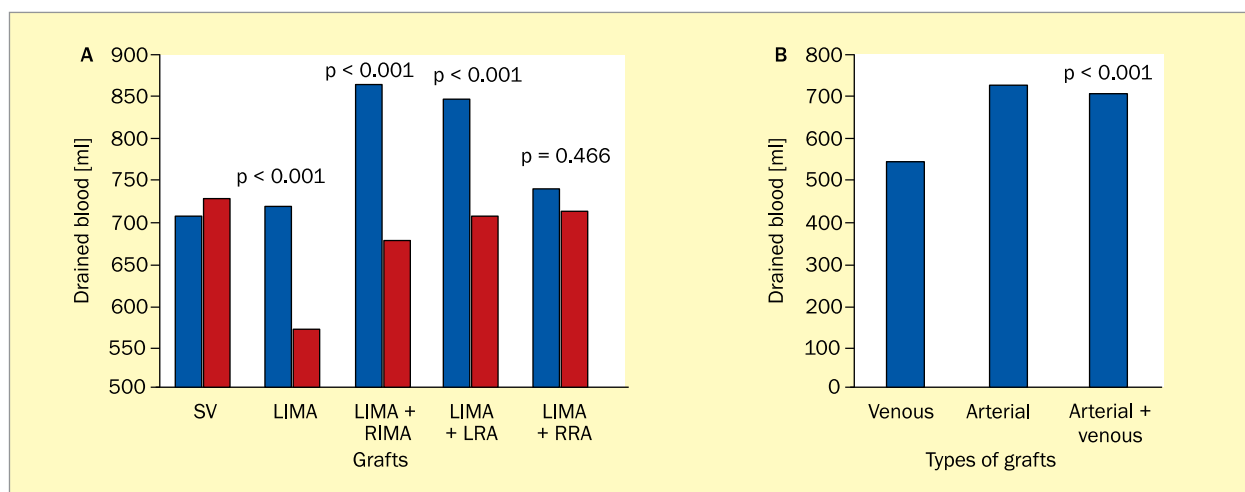
Among factors elevating mediastinal drainage in the first day after the surgery were: advanced CAD, admission of clopidogrel at least 5 days before surgery and arterial grafts (Table 1, Figures 2 and 3). Patients had also higher mediastinal drainage when grafted: left internal mammary artery (LIMA), LIMA and right internal mammary (RIMA), as well as LIMA and left radial artery (LRA) ( $p < 0.001$ ) (Figure 3). Moreover, factors elevating mediastinal drainage were: lower BMI (acc. to World Health Organization [WHO]

**Table 1.** Risk factors for postoperative bleeding

Parameter	Present parameter [mL]	Absent parameter [mL]	<i>p</i>
Hypertension (yes/no)	$699.7 \pm 400.7$	$776.4 \pm 516.3$	0.003
Diabetes mellitus (yes/no)	$717.8 \pm 462$	$715.2 \pm 380.9$	0.263
Extracardiac arteriopathy (yes/no)	$711 \pm 430.3$	$718.8 \pm 430.3$	0.476
Ejection fraction > 50%	$693.8 \pm 370.5$	$744.6 \pm 491.8$	0.375
Ejection fraction 30–50%	$737.4 \pm 488.8$	$702.1 \pm 382.6$	0.657
Ejection fraction < 30%	$763.6 \pm 512.8$	$714.7 \pm 426.2$	0.933
Creatinine > 2.3 mg/dL	$869.5 \pm 605.1$	$710.8 \pm 421.1$	0.203
Clopidogrel < 5 days preoperatively (yes/no)	$698.8 \pm 408.1$	$879 \pm 569.9$	0.003



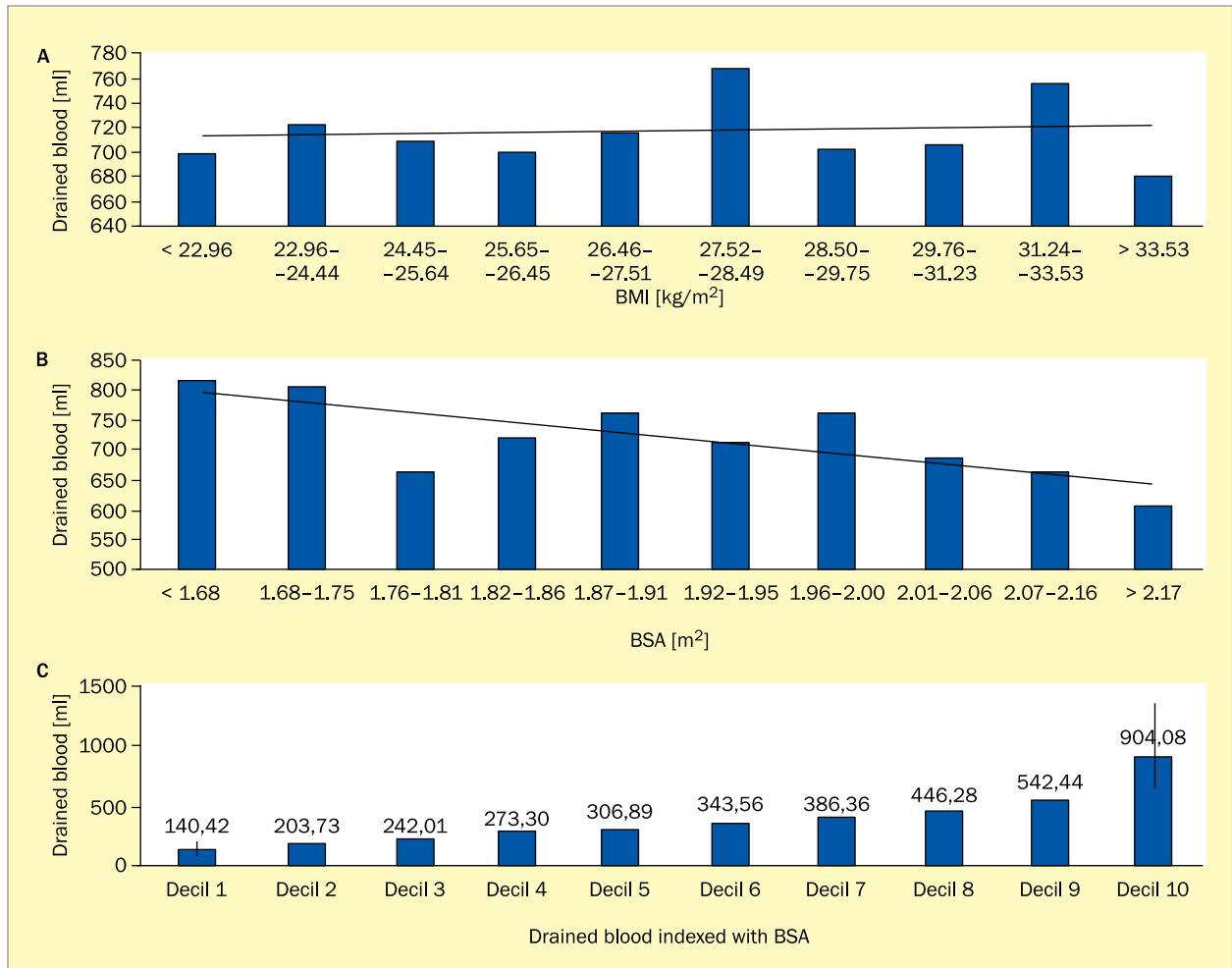
Figures 2A-E. Risk factors for postoperative bleeding; BMI – body mass index; ACS – acute coronary syndrome



Figures 3A, B. Chest tube drainage analyzed according to A types of transplanted grafts and B type of grafts; blue label when grafted; red label – not grafted; SV – saphenous vein; LIMA – left internal mammary, RIMA – right internal mammary; LRA – left radial artery; RRA – right radial artery

groups) of operated patients (rho-Spearman Index  $-0.06$ ,  $p = 0.023$ ), even lower value of the additive EuroScore (rho-Spearman Index  $-0.11$ ,  $p < 0.001$ ) and logistic EuroScore

(rho-Spearman Index  $-0.1$ ,  $p = 0.001$ ), longer duration of operations (rho-Spearman Index  $0.15$ ,  $p < 0.001$ ), and increasing number of grafts (rho-Spearman Index  $0.13$ ,



**Figures 4A–C.** Chest tube drainage analyzed according to: body mass index (BMI) deciles (A), body surface area (BSA) deciles (B), indexed BSA deciles (C)

$p < 0.001$ ), however the correlation was not strong. When analyzed according to deciles of BMI and BSA, the higher drainage was found, the higher BMI decile was noted, but the lower BSA was noted (both for BMI and BSA retrospectively,  $p < 0.0001$ ) (Figure 3). Finally, among deciles 2 and 3, 3 and 4, 4 and 5, 5 and 6, 6 and 7 differences were not found and the results were similar to non-indexed values ( $p < 0.001$ ) (Figure 4).

The overall regression model showed that patients who had greater amount of blood drained had: lower value of BMI ( $p < 0.001$ ), received clopidogrel more often ( $p < 0.001$ ), grafted bilateral internal mammary arteries (BIMA) ( $p < 0.001$ ) and longer lasting operation ( $p < 0.001$ ).

## Discussion

In our study, 76 patients (6%) required reoperation within 24-h due to excessive bleeding. This affects final clinical outcome of treatment as patients undergoing re-exploration due to postoperative bleeding have higher mortality and

longer hospitalization [1, 4, 5]. To achieve reliable results we eliminated two risk factors. We eliminated impact of surgeon's experience on results of treatment [7] by including into the study patients operated only by a single, experienced cardiac surgeon. Moreover, we excluded patients operated on-pump, which it is another important risk factor for postoperative bleeding [2, 4, 8].

Using LIMA to bypass the left anterior descending artery is a standard practice in coronary surgery. Such a technique has proven better both clinical and angiographic outcomes [9, 10]. Moreover, patients receiving BIMA in comparison to those receiving one internal mammary artery have decreased risk of death by 6.3% and decreased risk of reoperation by at least 8.3% in 12-year observation [11]. Using BIMA a surgeon has a chance for full arterial revascularization. It is naturally connected with more anastomosis, which also prolongs the time of operation [12] even in hands of an experienced surgeon. Such a procedure increases the risk of higher postoperative bleeding, which was shown in our study.

Patients with diabetes had also higher mediastinal drainage. Such an observation results most likely from the complications of the disease itself. In this group of patients, there can be usually found advanced and diffused CAD. Moreover, it predisposes to renal insufficiency [13], which is a postoperative bleeding risk factor itself [1]. Therefore, including that postoperative bleeding is also higher in older patients (> 75 years) [8], both parameters more often met in diabetic patients, our results supplement their clinical profile.

In our study, patients with lower BMI had higher risk for increased postoperative bleeding. Such a result is in agreement with previous results [1, 14]. Moreover, some authors showed that lower BSA is also a risk factor of higher drainage [4]. We have found that patients, whom BSA was noted in the first deciles, had higher drainage than those found in the last ones. We believe that such an observation can result from higher volume of blood in obese patients. This could be influenced by factors affecting hemostasis such as platelets and coagulation factors. It is known that obese patients with severe hemophilia (PWH) use 1.4 times more clotting factors concentrate/patient-month than non-obese patients. Moreover, in obese vs. non-obese PWH, higher level of von Willebrand factor plasma concentration, factor VIII activity, endogenous thrombin potential and plasminogen activator inhibitor type 1 levels can be found [15]. However, as shown in Figure 1, patients with BMI < 18.5 kg/m<sup>2</sup> had also low chest tube drainage but this group is too small to analyze in comparison to other 'BMI groups' (0.006% of population).

Surprisingly, we have found that reoperated patients were hospitalized for shorter time in ICU. This results from higher mortality in this particular group. It is well known that such complication prolongs hospitalization in ICU and total hospitalization [16], which was confirmed in our study.

## Limitations of the study

Our study has several limitations. We had missing information on aspirin admission in most of urgent and emergency operations, whereas most of elective surgeries were performed on patients receiving aspirin. Patients were qualified for reoperation when excessive bleeding was found (drainage > 200 mL/h in the first 4 postoperative hours), however the decision was also undertaken individually. This protocol of qualification to reoperation shows clinical difficulties in everyday practice. We did not analyze the impact of oral anticoagulants on postoperative bleeding as in our data base information on parameters as international normalized ratio (INR) or activated partial thromboplastin time (APTT) was missing. However, low-molecular-weight heparin (LMWH) administered before the surgery did not increase amount of drained blood within 24-h postoperatively (administered vs. not administered respectively 240 vs. 1,013; p = 0.202). We analyzed only PRBC transfusions but we did not collect information on amount of fresh frozen plasma units, platelet concentrate and coagulation factor concentrates.

## Conclusions

Our results suggest that overweight and obese patients have significantly decreased risk of increased blood drainage. Lost blood should be probably considered an indexed parameter, however our observation needs further evaluation. Surgeons should pay special attention to patients with diabetes, patients with multivessel disease and those who had BIMA used as grafts.

## Conflict of interest

None declared.

## Streszczenie

**Wstęp.** Celem pracy jest identyfikacja czynników ryzyka krwawienia pooperacyjnego po zabiegu pomostowania aortalno-wieńcowego bez użycia krążenia pozaustrojowego (OPCAB).

**Materiały i metody.** Badanie to retrospektywna, przekrojowa analiza obejmująca wszystkich pacjentów leczonych w Klinice Kardiologii Warszawskiego Uniwersytetu Medycznego (WUM) w latach 2004–2008 (2827 chorych). Kryterium włączenia do badania stanowił OPCAB z dostępu przez sternotomię pośrodkową; operatorem był ten sam kardiolog. Kryteriami wykluczającymi z badania były: konieczność rozszerzenia zakresu operacji o dodatkowe procedury kardiologiczne, konwersja z zabiegu bez zastosowania krążenia pozaustrojowego do zabiegu w krążeniu pozaustrojowym, zabieg wykonywany przez innego kardiologa. Do badania włączono ostatecznie 1253 pacjentów przyjętych z powodu choroby wieńcowej. Analizę statystyczną przeprowadzono na podstawie danych mierzalnych i niemierzalnych w analizowanych podgrupach. Wykonano również regresję logistyczną, w której mierzalnym parametrem był drenaż krwi w pierwszej dobie po operacji. Za istotne statystycznie uznano parametry, których p było niższe od 0,05.

analiza danych dotyczących tak powszechnego czynnika ryzyka krwawień pooperacyjnych, jakim jest standardowe leczenie kwasem acetylosalicylowym u pacjentów z przewlekłą chorobą wieńcową, jak należy sądzić, także w badanej grupie [5].

Pragnę pogratulować Autorom dobrego artykułu; z prawdziwą przyjemnością rekomendowałem Redaktor Naczelnej, Pani prof. Beacie Wożakowskiej-Kapton, i Radzie Redakcyjnej „Folia Cardiologica” przyjęcie tej pracy do druku z wysokim priorytetem. Biorąc pod uwagę wciąż dominującą liczbę operacji wieńcowych w corocznie raportowanym dorobku polskiej kardiologii, wszelkie wysiłki służące obniżeniu ryzyka powikłań, w tym wczesnych krwawień pooperacyjnych w grupie pacjentów po OPCAB, mają wielkie znaczenie dla jakości opieki i poprawy bezpieczeństwa leczonych chorych [6].

Mam nadzieję na kontynuację i szerszą analizę czynników ryzyka tak ważnego zagadnienia, jaki jest krwawienie pooperacyjne w kardiologii, nie tylko u pacjentów operowanych z powodu choroby wieńcowej. Pragnę zaprosić i zachęcić do dyskusji na łamach nowego działu „Kardiologia” w „Folia Cardiologica”.

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