Scandinavian Cardiovascular Journal

ISSN: 1401-7431 (Print) 1651-2006 (Online) Journal homepage: informahealthcare.com/journals/icdv20

Postcardioplegia ventricular fibrillation: No impact on subsequent survival

Sven Martin Almdahl, Terje Veel, Magne Eide, Jens Damstuen, Per Halvorsen & Per Mølstad

To cite this article: Sven Martin Almdahl, Terje Veel, Magne Eide, Jens Damstuen, Per Halvorsen & Per Mølstad (2014) Postcardioplegia ventricular fibrillation: No impact on subsequent survival, Scandinavian Cardiovascular Journal, 48:4, 249-254, DOI: 10.3109/14017431.2014.922212

To link to this article: https://doi.org/10.3109/14017431.2014.922212

Published online: 12 Jun 2014.

Scandinavian Cardiovascular Journal, 2014; 48: 249–254

informa
healthcare

ORIGINAL ARTICLE

Postcardioplegia ventricular fibrillation: No impact on subsequent survival

SVEN MARTIN ALMDAHL[1,2], TERJE VEEL[1], MAGNE EIDE[1], JENS DAMSTUEN[1], PER HALVORSEN[1] & PER MØLSTAD[3]

[1]*Department of Cardiac Surgery, Feiring Heart Clinic, Feiring, Norway,* [2]*Department of Cardiothoracic and Vascular Surgery, University Hospital of North Norway, Tromsø, Norway, and* [3]*Department of Cardiology, Feiring Heart Clinic, Feiring, Norway*

Abstract

Objectives. At aortic declamping after cardioplegic cardiac arrest, the initial rhythm can be broadly classified as ventricular fibrillation (VF) or non-VF. VF can be treated with potassium-induced conversion and direct-current countershock is only applied if potassium treatment fails. We aimed to investigate whether there are any differences between these groups of patients in regard to outcomes. *Design.* From January 1999 through December 2010, 12,113 patients underwent various types of cardiac surgery. Data from every patient were consecutively registered. Survival was established through the Norwegian National Registry. Cox multivariable modeling with adjustment for clinical, biochemical, and medication baseline data was used for survival analysis. *Results.* The mean follow-up time was 7.4 years and total patient-years were 89,268. The percentage of all-cause deaths was 24.9. Adjusted survival for patients with no postcardioplegia VF ($n = 9723$) and patients with successful potassium-induced conversion ($n = 1877$) was completely identical. Four hundred patients with electrical conversion after failed potassium treatment had a nonsignificant trend toward an increased mortality (hazard ratio, 95% confidence interval: 1.19 (0.99–1.4); $p = 0.07$). *Conclusions.* This is the first study reporting the association between postcardioplegia VF, its treatment with potassium and outcome. No impact was found on outcome as judged by all-cause mortality.

Key words: *cardioplegia, conversion, outcome, potassium, ventricular fibrillation*

Introduction

The ideal rhythm at aortic declamping after cardioplegic cardiac arrest on cardiopulmonary bypass (CPB) is sinus. It is generally considered that the prompt resuming of this normal rhythm without episodes of ventricular dysrhythmias is an indicator of optimal myocardial protection (1). However, the initial postcardioplegia rhythm is frequently ventricular fibrillation (VF). In a recent paper, the incidence of VF after aortic declamping was reported to be between 45% and 100% in a variety of cardiac surgical procedures (2). VF might have an adverse impact on the myocardium and treatment options such as giving amiodarone or lidocaine before reperfusion have been tried to decrease the VF frequency (2,3).

Direct-current countershock has been the traditional treatment of postcardioplegia reperfusion VF. It may possibly be harmful by inducing conceivable minor damage to myocytes (4,5). A convenient and to a high-degree successful alternative to electrical defibrillation is infusion of potassium into the perfusion line (6,7). Potassium infusion is our first-hand option for conversion of post-arrest VF. The advantage of giving potassium compared with the somewhat more cumbersome conventional electrical defibrillation is that the operative procedure can proceed without interruption, with no risk of injury to grafts by paddles or minor myocardial necrosis due to electrical current. With this perioperative management strategy, we recently reported that only

Correspondence: Dr. Sven Martin Almdahl, Department of Cardiothoracic and Vascular Surgery, University Hospital of North Norway, 9038 Tromsø, Norway. Tel: + 47–77627396. Fax: + 47–77628298. E-mail:sven.m.almdahl@unn.no

(Received 20 February 2014; revised 27 April 2014; accepted 1 May 2014)

ISSN 1401-7431 print/ISSN 1651-2006 online
DOI: 10.3109/14017431.2014.922212

355 patients (4%) of 8465 adult cardiac operated patients needed electrical defibrillation (7).

A description and comparison of early and late outcomes of patients with no postcardioplegia VF compared to patients with successful potassium-induced VF conversion and those with unsuccessful potassium conversion have scarcely been addressed in the literature, and is the purpose of the present study. The hypothesis was that postcardioplegia VF might be a predictor of a worse short- and long-term prognosis.

Material and methods

The study was approved by the institutional review board.

On January 1, 1999, a patient computerized database was established and preoperative, intraoperative, and postoperative data were consecutively entered. The database is maintained routinely in our clinic to document all cardiac surgical activity waiving specific written individual patient consent.

All patients undergoing any type of cardiac surgical operation on CPB in the period between January 1, 1999, and December 31, 2010, were enrolled in the study. Anesthesia, operative procedures, and postoperative care were standardized throughout the study interval as described (7). The operations were undertaken on CPB with non-pulsatile flow at moderate hypothermia (except a few aortic replacement procedures in circulatory arrest). After aortic cross-clamping, cold crystalloid St. Thomas II cardioplegia was delivered solely antegradely and repeated every 20 min during the time of cross-clamping. Retrograde administration of cardioplegia or blood cardioplegia was not used. Anti-arrhythmic drugs were not given before release of the aortic clamp. At the time of aortic declamping, the principle of gentle reperfusion was applied. If postcardioplegia VF occurred, 20 mmol (20 ml) of potassium chloride was given through the sampling line into the venous oxygenator reservoir and infused into the proximal aorta via the arterial line and this was done within 1 min after the start of reperfusion. If VF sustained, 10 mmol more potassium chloride was added. Persisting VF thereafter implied electrical conversion by intrapericardial paddles. Potassium treatment was performed on a routine basis and due to simplicity without any prior sophisticated calculations or consideration of systemic potassium values. However, in a retrospective analysis we found that there were no significant intergroup differences in serum potassium values preoperatively or on-pump before aortic declamping, as recently reported (7).

Study groups

Group 1 consisted of 9723 patients (80.3%) without VF at unclamping of the aorta, Group 2 of 1877 patients (15.5%) with postcardioplegia VF with successful potassium-induced conversion, and Group 3 of 400 patients (3.3%) with failed potassium conversion and thus in need of electrical conversion, which always was successful. A minor group of 113 patients (0.9%), where the surgeon selected to perform electrical defibrillation as the first-hand measure without trying conversion by potassium infusion was excluded. The treatment of these patients can be viewed as protocol violations as they were treated contrary to the guidelines of the institution. They constitute a small selected subgroup where the reason for deviation from guidelines was difficult to assess retrospectively. The possible conclusions to be drawn from this diminutive group were undefined and the treatment outcome would say more about the selection of patients than the chosen treatment.

Endpoints

The endpoints were 30-day mortality and long-term all-cause mortality. The survival status was established through the Norwegian National Registry, assuring a complete follow-up.

Statistical methods

Continuous variables were assessed with the skewness and kurtosis test for normality and, if differing from normal distribution, were evaluated using the Kruskal–Wallis test for difference between the groups, otherwise one-way analysis of variance was used. Categorical variables were assessed using Fisher's exact test or chi-square test as appropriate. In univariable analyses of long-term survival, the Kaplan–Meier product limit estimator and log-rank tests were used, and survival adjusting for baseline risk factors was evaluated in a multivariable Cox proportional hazard model. The Cox model was built using a manual forward selection technique from all baseline variables, selecting the variable with the highest value of Wald statistic at each step. Variables were kept in the model if the p-value was less than 0.05. After the selection of the significant main effects all included variables were tested for interaction and included in the model if found statistical significant and biological interesting. The different VF groups were thereafter forced into the model as categorical variables with Group 1 as the reference category. Continuous covariates were evaluated for linearity in log hazard by being categorized into quartiles and plotted against in hazard. The

proportional-hazard assumption in the Cox model was checked by tests based on the Schoenfeld residuals and log–log plots. All analyses were conducted with the use of STATA software version 12 (College Station, Texas, USA). The significance level was set at p less than 0.05.

Results

The baseline data are given in Table I and the postoperative outcomes are shown in Table II. There was no difference in the 30-day mortality, evaluated univariately or after multivariable Cox regression analyses (not shown).

Long-term mortality

The mean follow-up time was 7.4 years (range: 0–14.3) and the total time at risk for the whole cohort was 89,268 patient-years. The total number of all-cause deaths was 2962 (24.9%). Unadjusted survival was lower in Group 3 compared to that in Groups 1

Table I. Baseline variables.

Variable	No VF $n=9723$ (Group 1)	VF converted with K^+ $n=1877$ (Group 2)	VF not converted with K^+ $n=400$ (Group 3)	P value
Age years	67.9 ± 10.1	65.9 ± 9.9	65.1 ± 10.5	<0.001
Male %	72.7	82.7	91.0	<0.001
Elective surgery %	75.6	75.3	69.0	0.013
CABG %	90.4	94.0	91.3	<0.001
AVR %	17.7	10.5	15.0	<0.001
Mitral valve operation %	1.7	0.6	1.3	<0.001
CABG plus AVR or mitral surgery %	10.5	5.1	7.8	<0.001
Redo surgery %	3.3	3.6	7.0	<0.001
CPB minutes	52.2 ± 22.9	47.8 ± 21.5	55.7 ± 27.5	<0.001
Arrest time minutes	33.7 ± 17.5	29.5 ± 15.8	33.9 ± 20.8	<0.001
Diabetes %	17.2	16.3	16.3	0.608
Pulmonary disease %	13.3	13.9	15.5	0.368
Hypercholesterolemia %	78.3	80.5	76.5	0.066
Hypertension %	52.8	55.3	55.8	0.079
Unstable angina %	26.4	27.1	31.0	0.119
Previous infarction %	45.7	44.0	53.8	0.002
Previous PCI %	16.3	15.8	16.3	0.879
No coronary disease %	8.4	6.0	6.8	
One vessel disease %	5.0	4.0	3.8	
Two vessel disease %	17.2	18.1	21.4	
Three vessel disease %	69.4	72.0	68.1	<0.001
Ejection fraction	64.7 ± 13.3	65.3 ± 13.0	60.0 ± 15.0	<0.001
BMI	26.6 ± 3.9	27.6 ± 4.2	28.0 ± 4.2	<0.001
Euroscore	4.7 ± 3.2	4.0 ± 2.9	4.5 ± 3.2	<0.001
Logistic euroscore	5.9 ± 7.7	4.7 ± 6.3	6.0 ± 7.9	<0.001
ASA classification >3 %	34.1	28.2	36.8	<0.001
Betablocker %	76.4	77.9	80.0	0.110
Calcium antagonist %	20.3	24.5	24.5	<0.001
ACE inhibitor %	36.0	36.0	32.3	0.309
Diuretics %	19.3	16.0	24.8	<0.001
Statin %	71.9	73.0	68.5	0.176
Aspirin %	83.2	84.3	82.0	0.373
Clopidogrel %	21.1	19.4	18.2	0.126
Warfarin %	7.0	6.8	5.5	0.545
Hemoglobin g/dl	14.0 ± 1.4	14.3 ± 1.3	14.3 ± 1.5	<0.001
Creatinine µmol/l	93.2 ± 23.2	92.0 ± 19.0	93.7 ± 19.7	0.309
ASAT U/l	28.5 ± 17.8	28.5 ± 19.7	28.8 ± 16.9	0.881
ALAT U/l	33.7 ± 25.5	35.7 ± 27.9	36.6 ± 30.7	<0.001

Data presented as mean ± standard deviation or %; ACE, angiotensin-converting enzyme; ALAT, alanine aminotransferase; ASA, American Society of Anesthesiology; ASAT, aspartate aminotransferase; AVR; aortic valve replacement; BMI, body mass index; CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; PCI, percutaneous coronary intervention; VF, ventricular fibrillation.

Table II. Postoperative data.

Variable	No VF $n = 9723$ (Group 1)	VF converted with K^+ $n = 1877$ (Group 2)	VF not converted with K^+ $n = 400$ (Group 3)	*P* value
30-day mortality %	1.2	0.8	1.3	0.269
Myocardial infarction %	0.9	0.8	0.5	0.699
Stroke %	1.0	1.1	1.5	0.500
Ventilator >24 h %	0.9	0.7	0.5	0.737
Reopening for bleeding %	2.0	1.8	3.5	0.101
Reopening for mediastinitis %	0.5	0.6	0.8	0.600
Atrial fibrillation %	36.7	36.9	39.3	0.586
Inotropic drugs %	3.6	2.6	6.8	<0.001
IABP %	0.4	0.3	0.3	0.802
Blood transfusion %	35.3	24.3	28.8	<0.001
ASAT maximum U/L	72.9 ± 280.7	76.6 ± 483.9	64.7 ± 64.1	0.159
ALAT maximium U/L	53.1 ± 146.2	59.4 ± 337.2	49.7 ± 66.4	0.003
Creatinine maximum µmol/l	98.9 ± 37.7	96.2 ± 29.6	98.8 ± 30.7	0.164
Hemoglobin at discharge g/dl	10.8 ± 2.0	11.0 ± 2.3	11.0 ± 1.2	<0.001

Data presented as mean ± standard deviation or %; ALAT, alanine aminotransferase; ASAT, aspartate aminotransferase; IABP, intra-aortic balloon pump; VF, ventricular fibrillation.

and 2 (Figure 1). Using Cox proportional hazards regression for multivariable adjustment of baseline differences, the final model contained 17 main effects (Euroscore, age, ejection fraction, pulmonary disease, diabetes, gender, number of infarctions, unstable angina, hypercholesterolemia, hypertension, preoperative level of creatinine, hemoglobin, alanine aminotransferase, and aspartate aminotransferase, use of diuretics,—calcium antagonist, and—aspirin) in addition to VF groups. There was no statistical significant interactions with biological importance pertaining to these analyses, thus no interaction term was included in the model. The results showed no difference in survival (curves identical) between Groups 1 and 2. Group 3 had a nonsignificant trend toward an increased mortality, hazard ratio (HR) (95% confidence interval [CI]) 1.19, (0.99–1.4); $p = 0.07$ (Figure 2). The global test for proportional hazard based on Schoenfeld residuals was negative ($p = 0.081$).

In supplemental analyses CPB minutes, redo surgery, and the number of double procedures were tested in the multivariable model. The latter two had no significant impact. When CPB minutes were tested it was significant with a HR of 1.04 (95% CI: 1.03–1.06) for each 10 min increase in CPB time. However, it had a limited effect of the coefficients for the separate groups with a slight reduction in the HR for Group 3 from 1.19 to 1.16 with an increase in *p*-value from 0.07 to 0.131.

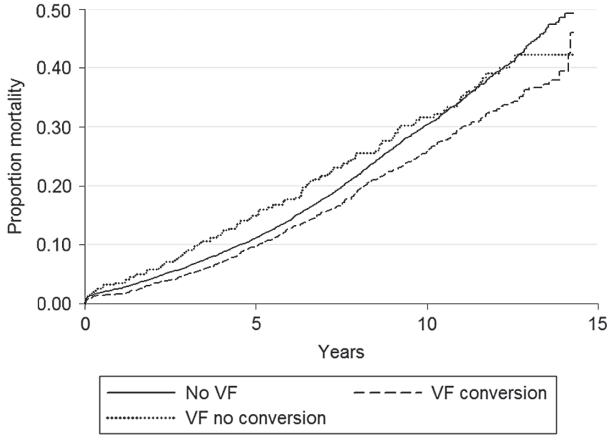

Figure 1. Kaplan–Meier failure estimates showing reduced unadjusted survival for the failed potassium treatment group ($p = 0.0006$, log-rank test).

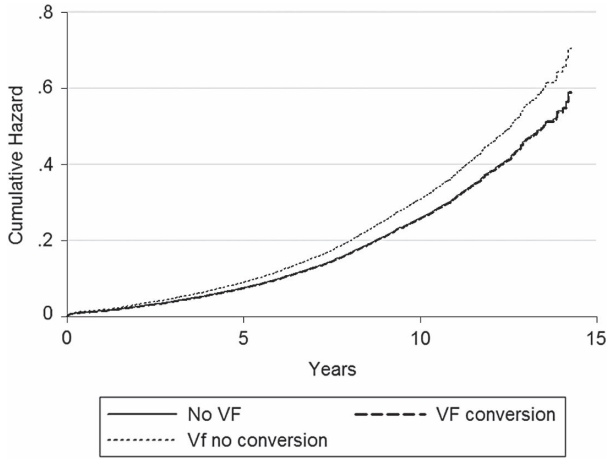

Figure 2. Cox proportional hazard regression analysis showing identical survival curves for patients without ventricular fibrillation and patients with successful potassium treatment. Patients with failed potassium treatment show a trend toward an increased mortality (HR, 1.19, 95% CI, 0.99–1.4; $P = 0.070$).

Discussion

The consequences of postcardioplegia VF on subsequent survival have remained to be elucidated and the underlying mechanism is still ill-understood. Adequate amount of cardioplegia with good protection of the myocardium during cardiac standstill is of importance to avoid reperfusion VF (7). If VF occurs, infusion of potassium will establish a non-fibrillating rhythm in a large proportion of the patients. DC conversion is required in quite a few patients. Electrical conversion is not recognized as a problem in daily practice and is the preferred method in many cardiac surgical units throughout the world. We hypothesized that postcardioplegia VF and its treatment could affect the prognosis. The hypothesis was not supported by our data after multivariate adjustment of baseline variables. A trend toward an increased risk of long-term mortality was observed in patients with DC conversion after failed potassium treatment, but this did not reach statistical significance after complete adjustments. The final survival curves for patients without postcardioplegia VF and patients with successful potassium-conversion were identical. Thus, postcardioplegia VF and its type of treatment is not a significant prognostic factor for all-cause short- and long-term mortality. Consequently, rigorous assessment of various therapies that prevent postcardioplegia VF does not seem to be imperative.

To our knowledge there are no data in the literature on the impact of postcardioplegia VF on outcome using Cox modeling adjusted for clinical, biochemical, and medication characteristics. According to a recent PubMed search, the present study seems to be the first to address this question. This is in contrast to a rather comprehensive literature on the impact of new-onset sustained ventricular tachycardia and fibrillation early in the postoperative course of cardiac operations (8,9), and of the influence of postoperative atrial fibrillation on long-term survival (10,11).

Elevated cardiac enzyme after cardiac surgery is a risk factor for inferior postoperative outcome (12). In our clinic, aminotransferases are exclusively used as cardiac markers due to tradition and cost benefits and because these enzymes also give a surveillance of the postoperative liver status. It is also routinely used by others in the contemporary era (13). More cardiac specific markers such as creatinine kinase MB isoenzyme (CK-MB) and troponins are available. These cardiac markers are not assessed at our center during the time frame of the study and it is the reason why they are not included in our analyses. We have found one publication describing the correlation between reperfusion VF during coronary artery bypass operations and its association with postoperative CK-MB release. CK-MB release correlated with the time spent in VF, but not with the number of times the patients required defibrillation (14). Only 20 patients were enrolled and no other outcome data were provided.

In another very early report the significance of intraoperative VF during aortic valve replacement and coronary arterial perfusion was studied in a series of 361 patients (15). The study showed a significantly greater early mortality rate in patients in whom VF developed during operation and in patients treated with countershock. This is mentioned although the relevance to VF after cardioplegia is of course questionable.

Potassium values are not included in this study. The subject was discussed in our recent report revealing no significant intergroup differences in this cohort of patients (7). Hence, the inclusion of serum potassium in our analyses is unlikely to affect the results.

The study has some limitations and possible strengths. The end-point was all-cause mortality and specific cardiac mortality was not retrieved which might have given other results. Influence of unidentified confounders may exist, as in all observational registry studies of this kind. The data are from one institution, limiting generalizability. The enrolled population is a case mix of different cardiac operations. The statistical methods deal with this and we wanted to study our complete patient pool reflecting daily real-life practice.

The cohort represents a rather large consecutive series without exclusions and with complete, long-term follow-up. The prospective nature of data collection protects against bias. The database is validated through internal data checks and audits by a surgeon and anesthesiologist independently.

Conclusion

In a large patient cohort undergoing a variety of cardiac surgical procedures postcardioplegia VF and its treatment strategy was not associated with increased early or late mortality.

Declaration of interest: The authors report no declarations of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Murrah CP, Ferguson ER, Spruell RD, Holman WL. Arrest duration influences postcardioplegia electrophysiologic recovery and reperfusion arrhythmias. Ann Thorac Surg. 1998;65:1003–8.

2. Mauermann WJ, Pulido JN, Barbara DW, Abel MD, Li Z, Meade LA, et al. Amiodarone versus lidocaine and placebo for the prevention of ventricular fibrillation after aortic cross-clamping: a randomized, double-blind, placebo-controlled trial. J Thorac Cardiovasc Surg. 2012;144:1229–34.
3. Samantaray A, Chandra A, Panigrahi S. Amiodarone for the prevention of reperfusion ventricular fibrillation. J Cardiothorac Vasc Anesth. 2010;24:239–43.
4. Runsjö M, Källner A, Källner G, Rosenquist M, Bergfeldt L. Myocardial injury after electrical therapy for cardiac arrhythmias assessed by troponin-T release. Am J cardiol. 1997;79:1241–5.
5. Yamaguchi H, Weil M, Tang W, Kamohara T, Jin X, Bisera J. Myocardial dysfunction after electrical defibrillation. Resuscitation. 2002;54:289–96.
6. Øvrum E, Tangen G, Holen EÅ, Ringdal M-AL, Istad R. Conversion of postischemic ventricular fibrillation with intraaortic infusion of potassium chloride. Ann Thorac Surg. 1995;60:156–9.
7. Almdahl SM, Damstuen J, Eide M, Mølstad P, Halvorsen P, Veel T. Potassium-induced conversion of ventricular fibrillation after aortic declamping. Interact Cardiovasc Thorac Surg. 2013;16:143–50.
8. Ascione R, Reeves BC, Santo K, Khan N, Angelini GD. Predictors of new malignant ventricular arrhythmias after coronary surgery: a case-control study. J Am Coll Cardiol. 2004;43:1630–8.
9. Yeung-Lai-Wah JA, Qi A, McNeill E, Abel JG, Tung S, Humphries KH, Kerr CR. New-onset sustained ventricular tachycardia and fibrillation early after cardiac operations. Ann Thorac Surg. 2004;77:2083–8.
10. Kaw R, Hernandez AV, Masood I, Gillinov AM, Saliba W, Blackstone EH. Short- and long-term mortality associated with new-onset atrial fibrillation after coronary bypass grafting: a systematic review and meta-analysis. J Thorac Cardiovasc Surg. 2011;141:1305–12.
11. Horwich P, Buth KJ, Légaré J-F. New onset postoperative atrial fibrillation is associated with a long-term risk for stroke and death following cardiac surgery. J Card Surg. 2013;28:8–13.
12. Lurati Buse GA, Koller MT, Grapow M, Bolliger D, Seeberger M, Filipovic M. The prognostic value of troponin release after adult cardiac surgery – a meta-analysis. Eur J Cardiothorac Surg. 2010;37:399–406.
13. Van Boxtel AGM, Bramer S, Hamad MAS, van Straten AHM. Perioperative serum aspartate aminotransferase level as a predictor of survival after coronary artery bypass grafting. Ann Thorac Surg. 2012;94:1492–9.
14. Lockerman ZS, Rose DM, Cunningham JN, Lichstein E. Reperfusion ventricular fibrillation during coronary artery bypass operations and its association with postoperative enzyme release. J Thorac Cardiovasc Surg. 1987;93:247–52.
15. Spanos PK, Brown AL, McGoon DC. The significance of intraoperative ventricular fibrillation during aortic valve replacement. J Thorac Cardiovasc Surg. 1977;73:605–10.