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Short paper

Aortic stenosis is an independent predictor for outcome in patients with in-hospital cardiac arrest

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Abstract

Background: Prognostic tools for decision-making whether to continue advanced life support or limit life sustaining interventions in In-Hospital Cardiac Arrest (IHCA), remain scarce and inconclusive. In this regard it seems intuitive that the presence of aortic stenosis (AS) impacts on both central and peripheral perfusion during resuscitative attempts and might worsen outcome. Therefore, we aimed to investigate the prognostic value of AS on outcome after IHCA.

Methods: Out of 11,641 patients presenting with acute coronary syndrome, a total of 151 patients were identified that received a standardized echocardiographic diagnostic immediately prior to an IHCA. Binary logistic regression analysis was used to elucidate the prognostic impact of AS on outcome.

Results: Within the entire study population, a total of 51 individuals with AS (mild: n = 19 [12.5%]; moderate: n = 11 [7.2%]; severe: n = 21 [13.8%]) were identified. We observed that 81% of patients with severe AS did not survive until hospital discharge. Additionally, the presence of AS showed a strong and independent inverse association with return of spontaneous circulation (adjusted odds ratio [OR] of 0.10 [95%CI:0.03–0.36], $p < 0.001$), survival (adj. OR of 0.14 [95%CI: 0.04-0.48]; $p = 0.002$) and favourable neurological outcome (OR of 0.16 [95%CI: 0.06-0.49]; $p = 0.001$). The observed prognostic impact remained stable irrespective of AS severity.

Conclusion: AS proved to be a strong and independent predictor for mortality and poor outcome after IHCA. Therefore, the presence of AS mirrors an easily available predictive tool for risk stratification and decision-making.

Keywords: In-Hospital cardiac arrest, Acute Coronary syndrome, Aortic stenosis, Outcome

Introduction

In-Hospital Cardiac Arrest (IHCA) represents a rare but dreaded complication in acute coronary syndrome (ACS).[1,2] Fatal arrhythmias resulting in IHCA occur in 1.6 per 1000 hospital admissions, with an overall unadjusted survival to hospital discharge of approximately 20%.[3,4]

While a large variety of substantial predictors for survival and favourable neurological outcome has already been investigated, less attention has been payed to pre-arrest findings in echocardiography.[5] As an easily assessable and feasible diagnostic tool, echocardiography provides profound information on cardiac functioning and valve morphology. In this context, aortic stenosis (AS) is the most common valvular heart disease in clinical practice with a prevalence of 1–3% in patients older than

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70 years.[6,7] Considering a potentially smaller valve orifice area in AS, it seems intuitive that both central and peripheral perfusion appear impaired during resuscitative attempts in cardiac arrest.

Since it remains a challenging approach to identify patients with a favourable prognosis without risking unnecessary suffering or harm, the presence of AS might be a suitable prognosticator for outcome that may be considered for risk stratification and decision making. However, there is no valid data in literature that investigated the prognostic impact of pre-arrest findings on aortic valve functioning in echocardiography on outcome after IHCA. Therefore, we aimed to investigate the prognostic value of AS on outcome in patients with signs of ACS presenting with IHCA.

Methods

Study population

A detailed study protocol has already been described elsewhere.[5] In short, a clinical registry of 11.641 patients presenting with signs of ACS that were admitted to the Vienna General Hospital, Austria, a university affiliated tertiary-care center with a high-volume cardiac catheterization unit, was used as the source database of the present analysis. The registry was screened for patients presenting with IHCA (n = 1167; 10.0%). A standardized echocardiographic diagnostic was performed in 151 (12.9%) cases immediately prior or within 2 months before IHCA.

The study protocol complies with the declaration of Helsinki and was approved by the local ethics committee of the Medical University of Vienna (EK 159/2011).

Data acquisition and follow-up

Patient characteristics were assessed at the time of hospital admission of the acute event. Digital medical records, including coronary angiographic diagnostics and intensive care unit (ICU) records were screened by especially trained chart reviewers and processed into a pre-designed record abstraction form. Blood samples were taken at time of admission and before coronary angiography and processed according to local laboratory standards (Department of Laboratory Medicine, Medical University of Vienna, Austria).

Definition of AS including the respective grading of severity was in accordance to the guidelines of the European Association of Cardiovascular Imaging.[8] ACS was defined in accordance to the guidelines of the European Society of Cardiology.[9,10] Cardiac Arrest was defined as any type of apnea and unresponsiveness resulting in resuscitative attempts. A arrhythmic cause of IHCA was defined as shockable first rhythm including ventricular fibrillation (VF) and pulseless ventricular tachycardia (pVT). Pump failure was defined as acute loss of blood pressure with preserved electric conduction in the ECG that lead to advanced resuscitative efforts. Survival until hospital discharge was defined as the primary study endpoint. Favourable neurological outcome was defined as a Cerebral Performance Category of 1 and 2 and evaluated by experienced personnel. Data acquisition of CA related data was conducted in accordance to the recommended Utstein-Style.[11]

Statistical analysis

Data were presented as median and interquartile range (IQR) for continuous data and counts and percentages for discrete data. Chi-square test was used to assess the association of categorical data. Comparisons of continuous data between subgroups were performed using t-test. Binary logistic regression analysis was used to assess the influence of AS on mortality and presented as odds ratios (OR) and the respective 95% confidence interval (CI). The multivariate model was adjusted for age, male gender, shockable electrocardiogram (ECG), ST-elevation myocardial infarction (STEMI), coronary intervention and vessel disease. Continuous variables were log-transformed before entering the model. Statistical significance was defined by two-sided p-values of <0.05. Statistical analyses were performed using SPSS 21.0 (IBM SPSS, USA).

Results

Detailed baseline characteristics for the entire study population and stratified in severity of AS are evident in Table 1. In short, out of those 151 patients with evident pre-arrest echocardiography, a total of 51 patients with AS (mild: n = 19 [12.5%]; moderate: n = 11 [7.2%]; severe: n = 21 [13.8%]) were identified. We found that a total of 44 (29.1%) individuals presented with cardiogenic shock at admission. Moreover, 112 (74.2%) patients arrested immediately after admission at the emergency department, 30 (19.8%) during PCI and 9 (5.9%) within 48 h after the admission. Of note, the overall distribution of the time of IHCA was comparable between subgroups of AS (p = 0.769). Pump failure trended to be to most prominent cause of cardiac arrest (71.5%) mirroring the vast majority in the severe AS subgroup (85.7%).

Baseline characteristics proved to be balanced between subgroups including patient characteristics, comorbidities and clinical presentation during the acute event.

Out of 151 IHCA cases, a total of 57 patients (37.7%) were discharged alive and 41 (27.2%) with favourable neurological outcome. Of note, while 47% of patients free of AS survived until hospital discharge, we observed that 81.0% of patients with severe AS died during hospitalization (p = 0.005). Similar findings were evident for favourable neurological outcome. One survivor with severe AS (4.8%) had favourable neurological outcome at the time of discharge, a total of 36 patients (36.0%) showed a favourable CPC of 1/2 in individuals free of AS (p = 0.002) (Table 1).

We observed that any AS significantly decreased the likelihood of reaching a return of spontaneous circulation (ROSC) with an adjusted OR of 0.10 (95%CI: 0.03–0.36; $p < 0.001$). Additionally, the presence of any AS had a strong and independent inverse effect on survival until discharge within the entire study population with an adjusted OR of 0.14 (95%CI: 0.04–0.48; p = 0.002). Similarly, AS proved to have a strong and independent inverse effect on favourable neurological outcome after IHCA with an adjusted OR of 0.16 (95%CI: 0.06–0.49; p = 0.001). Subsequent stratification into the respective grade of AS showed no modification of the prognostic value of AS for the odds of ROSC, survival or favourable neurological outcome (Table 2).

Discussion

Aortic stenosis and outcome after cardiac arrest

Whereas a variety of publications have assessed sudden cardiac death as a complication of AS, the present study represents– to the best of our knowledge– the first in literature that proved the prognostic value of AS after IHCA.[7]

Peri-resuscitative interventions such as manual/mechanical chest compressions or extracorporeal life support with the aim of optimal

Table 1 – Baseline characteristics.

	Free of AS	Mild & moderatr AS	Severe AS	p-Value
Vmax, m/s (IQR)	- (-)	2 (2–3)	5 (4–5)	**<0.001**
Mean gradient, mmHg (IQR)	- (-)	14 (11–22)	56 (43–72)	**<0.001**
LV Hypertrophy, n (%)	64 (64.0)	22 (73.3)	17 (81.0)	0.252
Clinical characteristics				
Age, years (IQR)	68 (57–77)	71 (58–75)	75 (67–77)	0.154
Male gender, n (%)	75 (75.0)	13 (43.3)	10 (47.6)	**0.001**
BMI, kg/m^2 (IQR)	25.4 (22.3–27.7)	22.5 (20.8–28.0)	25.6 (24.1–26.9)	0.327
HR at admission, bpm (IQR)	76 (66–90)	81 (68–91)	80 (71–88)	0.595
SBP at admission, mmHg (IQR)	125 (110–135)	130 (110–149)	126 (110–140)	0.728
DBP at admission, mmHg (IQR)	77 (70–85)	80 (71–87)	77 (60–80)	0.316
Cardiogenic shock at admission, n (%)	28 (28.0)	9 (30.0)	7 (33.3)	0.881
STEMI, n (%)	47 (47.0)	12 (40.0)	9 (42.9)	0.718
Coronary intervention, n (%)	55 (55.0)	15 (50.0)	15 (71.4)	0.286
Vessel disease				0.939
I VD, n (%)	29 (53.7)	8 (53.3)	7 (46.7)	
II VD, n (%)	11 (20.4)	2 (13.3)	3 (20.0)	
III VD, n (%)	14 (25.9)	5 (33.3)	5 (33.3)	
Time to cardiac arrest				0.769
Immediately after admission, n (%)	74 (74.0)	24 (80.0)	14 (66.7)	
During PCI, n (%)	20 (20.0)	4 (13.3)	6 (28.6)	
<48 h after admission, n (%)	6 (6.0)	2 (6.7)	1 (4.7)	
Witnessed CA, n (%)	99 (99.0)	29 (96.7)	21 (14.1)	0.525
Cause of Cardiac Arrest				0.281
Arrhythmic/ Shockable ECG, n (%)	30 (30.0)	10 (33.3)	3 (14.3)	
Pump failure, n (%)	70 (70.0)	20 (66.7)	18 (85.7)	
GCS <8 after ROSC, n (%)	34 (61.8)	5 (83.3)	1 (25.0)	0.177
TTM initiated, n (%)	32 (32.0)	4 (13.3)	1 (4.8)	**0.009**
TTM reached, n (%)	15 (15.0)	4 (13.3)	1 (4.8)	0.453
Hypertension, n (%)	59 (59.0)	16 (53.3)	7 (33.3)	0.099
Diabetes Mellitus Type II, n (%)	11 (11.0)	2 (6.7)	4 (19.0)	0.384
Hypercholesterolemia, n (%)	9 (30.0)	10 (47.6)	0.180	
Previous AMI, n (%)	13 (13.0)	5 (16.7)	1 (4.8)	0.441
Family History of CVD, n (%)	26 (26.0)	1 (3.3)	5 (23.8)	**0.027**
Troponin-T, max. µg/l (IQR)	0.72 (0.16–1.65)	1.17 (0.20–2.79)	0.66 (0.28–2.29)	0.822
Creatin Kinase, max. U/l (IQR)	135 (312–800)	221 (607–1108)	467 (129–1085)	0.165
Outcome Measures				
Sustained ROSC, n (%)	55 (55.0)	6 (20.0)	4 (19.0)	**<0.001**
Survival, n (%)	47 (47.0)	6 (20.0)	4 (19.0)	**0.005**
CPC 1 and 2, n (%)	36 (36.0)	4 (13.3)	1 (4.8)	**0.002**

Categorical data are presented as counts and percentages, continuous data as medians and IQRs. Categorical data are analyzed using a test for linear association (Maentel–Haenszel chi-square test), continuous data using Kruskal–Wallis test for testing within the subgroups. AMI = Acute Myocardial Infarction, BMI = body mass index, CA = Cardiac Arrest, CPC = Cerebral performance category, CVD = Coronary vessel disease, DBP = Diastolic blood pressure, GCS = Glasgow Coma Scale, LV = left ventricular, HR=Heart rate, SBP = Systolic blood pressure, STEMI = ST-elevation myocardial infarction, TTM = Target temperature Management, VD = vessel disease, Vmax = Maximum Doppler Velocity. Statistical significance is highlighted in bold values.

Table 2 – Binary logistic regression analysis.

	Sustained ROSC		Survival		Favourable Neurological Outcome	
	Adjusted OR (95%CI)	p-Value	Adjusted OR (95%CI)	p-Value	Adjusted OR (95%CI)	p-Value
Aortic stenosis (any)	0.10 (0.03–0.36)	<0.001	0.14 (0.04–0.48)	0.002	0.16 (0.06–0.49)	0.001
Aortic stenosis *(moderate/severe)*	0.14 (0.04–0.55)	0.005	0.16 (0.04–0.66)	0.011	0.13 (0.03–0.59)	0.009
Aortic stenosis (*severe)*	0.11 (0.02–0.61)	0.012	0.13 (0.02–0.72)	0.020	0.11 (0.01–0.85)	0.035

Binary logistic regression analysis for the association of aortic stenosis and outcome measures. The multivariate model was adjusted for: Age, male gender, shockable ECG, STEMI, coronary intervention and vessel disease.

cardiac output and cerebral and systemic perfusion are well known as the most crucial treatment approach in cardiac arrest to reach survival and favourable outcome.[12] In this regard it seems intuitive that, considering a potentially smaller valve orifice area in severe AS, the maximal possible cardiac output is significantly decreased during CPR and cerebral blood flow is diminished — subsequently leading to poor outcome. This assumption could be provided within the present investigation. Since the overall survival rate until discharge in IHCA of 37.7% in this study population is comparably higher than recently reported rates from international perspectives, the observed mortality in AS patients proved to be significantly worse.[1] While survival until discharge was reached in 47.0% of patients free of AS, survival rates decreased with increasing severity of valve disease resulting in an exceptionally poor survival rate of 19.0% in individuals presenting with severe AS. Similar findings were observed for the patients' neurological outcome at the time of hospital discharge, despite an evidence based therapeutic approach during post-ROSC care including a TTM in 92.5% of patients that presented with a GCS < 8. While having a CPC of 1/2 in 36% of all cases in the group free of AS, only a single patient in the severe AS population (4.6%) reached a favorable neurological outcome, underlining the strong impact of both inadequate systemic and especially cerebral perfusion.

Prognostic value for decision-making

Healthcare providers are often faced with an ethical dilemma in deciding for or against prolonged life-sustaining interventions during CA. International guidelines have broadly discussed the issue of ethics in resuscitation, end of life decision as well as prognostication. In this regard the patients' autonomy and the principle of beneficence need to be considered. The need to develop simple algorithms to guide healthcare providers in decision making and limit the burden of unnecessary and potentially painful medical interventions was highlighted.[2,13] Therefore, the presence of AS seems a reasonable and easily accessible prognostic value that can be added in a decision-making process.

Of utmost importance, several investigations found that elderly individuals that are confronted with end-of-life decisions fear the loss of autonomy and unfavourable physical and neurological conditions much more than death itself.[14,15] In this regard the observed low survival rate (19.0%) combined with exceptionally poor neurological outcome (4.8%) in patients with severe AS needs to be taken into account and cannot be ignored before or during life-sustaining interventions.

Limitations

The small sample size and the observational character of the study might temper the interpretation of our results. However, by obtaining valid data of a large clinical registry and demonstrating a significant effect of the impact of AS of outcome after a comprehensive adjustment for potential confounders, we can provide robust and relevant data on this topic.

Conclusion

The present investigation extended the current knowledge by demonstrating that the presence of AS proved to be a strong and independent predictor for poor outcome after IHCA. Since it remains a challenging approach to identify patients with a favourable prognosis without risking unnecessary suffering or harm, the presence of AS seems a rational prognosticator that can be considered for risk stratification and decision-making.

Founding sources

None.

Disclosures

None.

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