QRS complex findings in patients following out-of-hospital cardiac arrest with particular focus on their coronary status

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ABSTRACT

Background: There is still a lack of knowledge about the clinical relevance of electrocardiographic findings in patients following out-of-hospital cardiac arrest (OHCA). **Methods:** All victims of OHCA who were admitted to our hospital between January 1st 2008 and December 31st 2013 were identified and their QRS complexes were analyzed according to QRS duration and QRS morphology measured with the simplified Selvester Score. **Results:** A total of 147 out of 204 OHCA patients were included in our study, of which 76 received coronary angiography. The first 12-lead ECG showed a mean QRS duration of 108.0 ± 22.1 ms and 4.3 ± 3.5 points for the simplified Selvester Score. QRS complexes in patients following OHCA due to an initial shockable rhythm were significantly wider in patients who were discharged alive (114.0 ± 23.8 ms) than in patients who died in-hospital (98.9 ± 18.1 ms) (p=0.016), and patients who survived until the follow-up examination showed a significant reduction in the QRS duration (p=0.001), whereas the simplified Selvester Score showed no such changes. Subgroup analyses revealed that this reduction in QRS duration was most pronounced in patients with coronary artery disease (CAD) who received percutaneous coronary intervention (PCI). **Conclusion:** Neither QRS duration nor QRS morphology can reliably predict the prognosis of all patients following OHCA. However, as QRS durations decrease, especially in patients with CAD who receive PCI, it is possible that standardized QRS monitoring in patients following OHCA could be a useful tool in the monitoring of the hemodynamics of patients following OHCA.

Key words: out-of-hospital cardiac arrest, QRS duration, QRS morphology, simplified Selvester Score, post-resuscitation treatment, coronary artery disease.

INTRODUCTION

Several factors have been associated with a better prognosis following out-of-hospital cardiac arrest (OHCA): clinical factors such as witnessed arrest[1], initial shockable rhythm1, immediate lay resuscitation[2] and young age[3], along with laboratory test results such as a rapid decrease in lactate[4], persistent low Neuron Specific Enolase[5] and high arterial oxygen partial pressure.[6]

It has also been suggested that electrocardiographic findings such as wide QRS scores might have prognostic significance in predicting mortality following OHCA[7] but there are no data that differentiate between ischemic and non-ischemic myocardium. Previous studies suggest that primarily post-infarction patients with prolonged QRS duration have a significantly increased risk of mortality whereas in non-ischemic cardiomyopathy, there is no evidence that QRS duration has prognostic significance in predicting mortality.[8] We therefore initiated this study to explore the clinical relevance of QRS complex findings in patients following OHCA in both ischemic and non-ischemic hearts.

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MATERIAL AND METHODS

Data collection

All victims of OHCA who were admitted to our hospital

between January 1st 2008 and December 31st 2013 were identified by analysis of our central admission register. Individual patient data were collected from the patient`s health records and anonymously stored in a central database. Statistical analysis was performed using the Statistical Package of Social Science (SPSS 22.0, IBM, Armonk, NY, USA). Continuous variables are expressed as the mean ± SD, and comparisons of categorical variables among groups were conducted using Chi-square tests or Student`s t-test. P-values <0.05 were considered to be significant. Data collection and analysis were approved by the local ethical review committee.

ECG analysis

All patients received a 12-lead surface ECG after admission, except those patients under continued resuscitation efforts who never reached return of spontaneous circulation (ROSC). ECGs were recorded on Marquette MAC 1200 EKG machines (GE®, Marquette) at 50 Hz with a filter range between 0.08 and 150 Hz.

ECGs without intrinsic QRS due to continuous ventricular pacemaker stimulation, ventricular tachycardia or escape rhythm were excluded from further analysis

Conventional QRS durations were measured; additionally we analyzed the QRS complex morphology according to the simplified Selvester Score, which is a standardized QRS scoring system[9] that has been shown to correlate with the prognosis in patients with coronary artery disease.[10] This Score was chosen because of its simplicity, which enables all emergency physicians – including non-cardiologists – to conduct a rapid analysis of the QRS complex.

The combination of both QRS duration and QRS morphology was chosen to ensure that as many parameters of the QRS complex as possible were included in the evaluation of the information content of QRS complexes following OHCA.

Follow-up ECGs (FU) were analyzed between day 12 and 16 following OHCA as peri-infarction zones decrease up to 90 days, but are most pronounced from day 3 to 10.[11]

RESULTS

Patient data

Overall, 204 patients were admitted to our hospital between January 1st 2008 and December 31st 2013 following OHCA. Twenty-nine patients were excluded from further analysis due to missing 12-lead ECG as a consequence of incessant resuscitation efforts, four patients presented an ECG with continuous ventricular pacemaker stimulation, seven patients with ventricular tachycardia and five patients with ventricular escape rhythm. Twelve patients had to be excluded due to missing or incomplete data.

The remaining 147 patients were included in our analysis of the predictive value of QRS complex measurements on survival.

Additional analysis that considered the coronary status was performed in those 76 patients who also received coronary angiography: 45 men (59.2%) and 31 women (40.8%) with a mean age of 63.6 ± 13.4 years. In this group, 59 OHCA were witnessed (77.6%), lay resuscitation was initiated in 41 patients (53.9%) and 41 patients (53.9%) demonstrated an initial shockable rhythm. The first 12-lead ECG after hospital admission showed a heart rate of 90.0 ± 23.2 beats per minute (bpm), a QRS duration of 108.0 ± 22.1 ms and 4.3 ± 3.5 points in the simplified Selvester Score. Altogether, 38 of these patients (50.0%) had a myocardial infarction: 29 (38.2) a ST elevation myocardial infarction (STEMI), and nine (11.8%) a non-ST elevation myocardial infarction (NSTEMI).

Coronary angiography showed coronary artery disease (CAD) in 62 patients (81.6%), and 52 patients (68.4%) received percutaneous coronary intervention (PCI). Mild therapeutic hypothermia was induced in 47 patients (61.8%), and 43 patients (56.6%) survived until hospital discharge (Table 1).

Correlation of QRS complex findings and survival of patients following OHCA

The QRS duration and simplified Selvester Score did not differ between OHCA patients who survived until hospital discharge and patients who died in-hospital, either in general, or in subgroups of patients with CAD or those who received PCI. There was one exception: QRS complexes were significantly wider in patients who were discharged alive following OHCA due to an initial shockable rhythm (114.0 ± 23.8 ms) than in patients who died in-hospital following OHCA due to an initial shockable rhythm (98.9 ± 18.1 ms) (p=0.016) (Table 2).

Changes in the QRS complex during follow-up

Thirty-six patients received coronary angiography, 12-lead ECG at admission and at the follow-up examination between day 12 and 16: 22 men (61.1%) and 14 women

Table 1: Characteristics of all 76 patients who received 12-lead ECG at admission and coronary angiography following OHCA

	Patients who received 12-lead ECG and coronary angiography (n = 76)
Male, n (%)	45 (59.2%)
Age (years) [range]	63.6 ± 13.4 [31–88]
Witnessed cardiac arrest, n (%)	59 (77.6%)
Lay resuscitation, n (%)	41 (53.9%)
Shockable rhythm, n (%)	41 (53.9%)
Heart rate (bpm) [range]	90.0 ± 23.2 [36–145]
QRS duration (ms) [range]	108.0 ± 22.1 [70–170]
Simplified Selvester Score (points) [range]	4.3 ± 3.5 [0–16]
Myocardial infarction, n (%)	38 (50.0%)
ST elevation myocardial infarction (STEMI)	29 (38.2%)
Non-ST elevation myocardial infarction (NSTEMI)	9 (11.8%)
Coronary artery disease (CAD), n (%)	62 (81.6%)
Percutaneous coronary intervention (PCI), n (%)	52 (68.4%)
Mild therapeutic hypothermia, n (%)	47 (61.8%)
Discharged alive, n (%)	43 (56.6%)

Table 2: Differences in the QRS complex findings in patients following OHCA who were discharged alive and those patients who died in-hospital

	Discharged alive		Died in-hospital		p
	n		n		
QRS duration (ms)					
All patients (n = 147)	61	106.4 ± 22.8	86	105.4 ± 20.9	0.787
First rhythm: ventricular fibrillation (n = 53)	31	114.0 ± 23.8	22	98.9 ± 18.1	0.016
First rhythm: asystole (n = 51)	14	99.6 ± 21.3	47	106.3 ± 20.7	0.297
Coronary artery disease (n = 62)	32	107.8 ± 21.7	30	107.3 ± 21.8	0.931
Percutaneous coronary intervention (n = 52)	26	107.1 ± 22.9	26	107.3 ± 22.9	0.976
Simplified Selvester Score (points)					
All patients (n = 147)	61	3.6 ± 3.2	86	4.1 ± 3.9	0.355
First rhythm: ventricular fibrillation (n = 53)	31	4.3 ± 3.7	22	4.4 ± 3.5	0.966
First rhythm: asystole (n = 83)	14	3.0 ± 2.1	47	4.1 ± 3.8	0.313
Coronary artery disease (n = 62)	32	3.8 ± 3.6	30	4.8 ± 3.7	0.294
Percutaneous coronary intervention (n = 52)	26	3.7 ± 3.0	26	4.7 ± 3.7	0.296

Table 3: Characteristics of those patients who survived until our follow-up examination and received coronary angiography as well as 12-lead ECG at admission and follow-up

	Patients who received 12-lead ECG at admission and follow-up as well as coronary angiography (n = 36)
Male, n (%)	22 (61.1%)
Age (years) [range]	59.8 ± 14.0[31–88]
Witnessed cardiac arrest, n (%)	27 (75.0%)
Lay resuscitation, n (%)	22 (61.1%)
Shockable rhythm, n (%)	23 (63.9%)
Heart rate (bpm) [range]	88.4 ± 23.0 [36–136]
QRS duration (ms) [range]	110.8 ± 22.8 [75–170]
Simplified Selvester Score (points)[range]	3.7 ± 2.9 [0–10]
Myocardial infarction, n (%)	19 (52.8%)
ST elevation myocardial infarction (STEMI)	13 (36.1%)
Non-ST elevation myocardial infarction (NSTEMI)	6 (16.7%)
Coronary artery disease (CAD), n (%)	28 (77.8%)
Percutaneous coronary intervention (PCI), n (%)	25 (69.4%)
Mild therapeutic hypothermia, n (%)	25 (69.5%)
Discharged alive, n (%)	31 (86.1%)

Table 4: Changes in the QRS complex findings following OHCA depending on time and coronary status

	At admission	At follow-up	p
QRS duration (ms)			
All patients who reached follow-up (n=36)	110.8 ± 22.8	98.2 ± 21.0	0.001
Patients with an initial shockable rhythm (n=23)	115.4 ± 23.6	99.6 ± 22.3	0.001
Patients with an initial non-shockable rhythm (n=13)	103.8 ± 20.0	97.1 ± 19.8	0.244
Patients with CAD (n=28)	110.5 ± 21.8	97.9 ± 21.0	0.002
Patients without CAD (n=8)	111.9 ± 27.5	99.4 ± 23.1	0.131
Patients with myocardial infarction (n=19)	109.2 ± 22.9	95.8 ± 21.4	0.006
Patients without myocardial infarction (n=17)	112.6 ± 23.3	100.9 ± 21.1	0.039
Patients with PCI (n = 25)	108.6 ± 22.1	98.4 ± 20.1	<0.001
Patients with CAD but without PCI (n = 3)	126.7 ± 11.5	93.3 ± 32.1	0.289
Simplified Selvester Score (points)			
All patients who reached follow-up (n = 36)	3.7 ± 2.9	3.7 ± 3.0	0.520
Patients with an initial shockable rhythm (n=23)	3.9 ± 3.1	3.5 ± 3.4	0.522
Patients with an initial non-shockable rhythm (n=13)	3.5 ± 2.6	3.2 ± 2.3	0.768
Patients with CAD (n = 28)	3.8 ± 3.1	3.7 ± 3.0	0.866
Patients without CAD (n = 8)	3.4 ± 2.5	2.1 ± 2.7	0.340
Patients with myocardial infarction (n=19)	4.6 ± 3.1	4.6 ± 3.0	0.944
Patients without myocardial infarction (n=17)	2.8 ± 2.6	1.9 ± 2.3	0.342
Patients with PCI (n = 25)	3.7 ± 3.1	4.0 ± 3.0	0.633
Patients with CAD but without PCI (n = 3)	4.7 ± 3.2	1.3 ± 2.3	0.405

(38.9%) with a mean age of 59.8 ± 14.0 years. There were 27 witnessed events (75.0%), lay resuscitation was performed in 22 patients (61.1%) and 23 presented an initial shockable rhythm (63.9%). The mean heart rate at admission was 88.4 ± 23.0 bpm. Nineteen patients (52.8%) presented with myocardial infarction: 13 (36.1%) with STEMI and six (16.7%) with NSTEMI.

Coronary angiography was performed in 28 of these patients (77.8%), 25 received PCI (69.4%) and 25 were treated with mild therapeutic hypothermia (69.5%). Overall, 31 patients (86.1%) were discharged alive (Table 3).

Patients who survived until the follow-up examination showed a significant decrease in the QRS duration from 110.8 ± 22.8 ms at admission to 98.2 ± 21.0 ms at follow-up (p=0.001). In contrast, the simplified Selvester Score showed no relevant changes, being 3.7 ± 2.9 points at admission and 3.7 ± 3.0 points at follow-up.

Further analysis revealed that a significant reduction in the QRS duration could be seen in patients with an initial shockable rhythm (115.4 ± 23.6 ms vs. 99.6 ± 22.3 ms; p=0.001), and in patients with CAD (110.5 ± 21.8 ms vs. 97.9 ± 21.0 ms; p=0.002) independently from the presence of acute myocardial infarction (109.2 ± 22.9 ms vs. 95.8 ± 21.4 ms; p=0.006 in patients with myocardial infarction and 112.6 ± 23.3 ms vs. 100.9 ± 21.1 ms; p=0.039 in patients without myocardial infarction). Altogether, QRS reduction between admission and follow-up was most pronounced in patients who received PCI (108.6 ± 22.1 ms vs. 98.4 ± 20.1 ms; p<0.001).

No significant decrease in the QRS duration was observed in patients with an initial non-shockable rhythm (103.8 ± 20.0 ms vs. 97.1 ± 19.8 ms), patients without CAD (111.9 ± 27.5 vs. 99.4 ± 23.1; p=0.131) or patients with CAD but no need for PCI (126.7 ± 11.5 ms vs. 93.3 ± 32.1 ms; p=0.289) (Table 4).

DISCUSSION

Despite promising initial data that indicated the possible prognostic significance of broad QRS scores in predicting mortality following OHCA[7], few studies have focused on QRS complex analysis following OHCA.

In our study, which included measurement of QRS duration as well as QRS complex morphology analyzed using the simplified Selvester Score, we found that the simplified Selvester Score failed both in terms of predictive value as well as its use as a follow-up marker. We therefore suggest that further studies that focus on the QRS morphology of patients following OHCA should utilize another ECG Score. However, analysis of the QRS duration following OHCA was promising.

Predictive value of QRS complex findings

As previous studies reported increased mortality in patients with a prolonged QRS duration in a standard 12-lead ECG, including in patients with heart failure,[12] coronary artery

disease[13], pulmonary artery hypertension[14] and even in the population in general,[15] we expected that a QRS complex analysis in patients following OHCA might provide helpful additional information for post-resuscitation treatment. Previous study results were promising and indicated a prognostic relevance of broad QRS scores in predicting mortality following OHCA, at least in patients who presented with an initial shockable rhythm.[7]

However, our results showed the exact opposite, as there was not one predictive value for survival in our QRS complex analysis, with the exception of a longer QRS duration in patients who survived until hospital discharge (Table 4).

Maybe, these differences could be attributed to the fact that QRS complexes in our study were 114.0 ± 23.8 ms and thus clearly shorter than those described previously (141 ± 41 ms in non-survivors and 123 ± 35 ms in survivors of OHCA).[7]

Anyway, in our opinion the most plausible, Bunch et al. studied patients following OHCA due to a shockable rhythm who received early lay defibrillation after 5.7 (survivors), respectively 6.6 (nonsurvivors) minutes.[7] None of our patients received lay defibrillation and only about half of them lay resuscitation. Consequently, even though we could not find out the exact durations of the individual resuscitation efforts in our patients, we act on the assumption that the circulatory arrests in our study group lasted longer. Therefore, wide QRS complexes in patients immediately after OHCA as observed in our study are probably caused by acute myocardial ischemia,[16] whereas those previously described QSR prolongations[7] might more reflect the expression of a preexisting myocardial dysfunction,[17] with different effects on the patient's prognosis.

QRS complex alterations at follow-up

In survivors of OHCA, initial hemodynamic instability is characterized by a low cardiac index that is reversible in most cases within 24 hours, suggesting post-resuscitation myocardial dysfunction.[18] Improvement in cardiac index was associated with better survival whereas early death was associated with a persistent low cardiac index at 24 hours.[18]

In our study, we observed a significant reduction in the QRS duration between admission and follow-up examination in those patients who survived until our follow-up examination. Subgroup analysis showed that this reduction was most pronounced in patients with CAD who received PCI, regardless of whether they had an acute myocardial infarction or not (Table 3).

This finding supports our hypothesis that as our 12-lead ECGs were obtained early after resuscitation they describe acute myocardial ischemia and not permanent myocardial damage.

However, this observation that QRS durations change over time, perhaps as an expression of myocardial recovery, suggests that continuous monitoring of the QRS duration might be a useful tool in estimating the course of disease in patients at an early stage after OHCA.

CONCLUSION

Altogether, our study results show that the first QRS complex in patients following OHCA is probably not suitable to predict the further course of disease. However, our data are also promising, in that the dynamic in the reduction of the QRS duration in patients following OHCA might be a useful tool to record hemodynamic stabilization. Therefore, we suggest further studies that focus on the recording of the QRS duration in parallel with other hemodynamic measurements in patients following OHCA.

DISCLOSURES

All authors declare: no conflict of interest.

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