Electrocardiographic findings of methanol toxicity: A cross-sectional study of 356 cases in Iran.

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Abstract

Bakground: Methanol is used widely in industry but methanol poisoning is not common; however, a number of outbreaks have been recently reported due to inappropriate processing of alcoholic beverages. Shiraz which is located in the southern part of Iran faced one of these in 2020 during COVID-19 pandemic. There is scarce literature on the electrocardiographic findings in methanol toxicity. The aim of this study is to address this gap in the literature.

Method: A total of 356 cases with methanol toxicity were referred to Shiraz University of Medical Science Tertiary Hospitals (Faghihi and Namazi) in March and April 2020. The clinical findings such as blindness and impaired level of consciousness, lab data such as arterial blood gas, electrolytes, and creatinine, and the most common findings from ECGs were collected.

Results: The most common ECG findings were J point elevation (68.8%), presence of U wave (59.2%), QTc prolongation (53.2% in males and 28.6% in females), and fragmented QRS (33.7%). An outstanding finding in this study was the presence of myocardial infarction in 5.3% of the cases, a finding which, to our knowledge, has only been reported in in a few case reports. Brugada pattern (8.1%) and Osborn wave (3.7%) were other interesting findings.

In multivariate analysis, when confounding factors faded, myocardial infarction, atrioventricular conduction disturbances, sinus tachycardia and a prolonged QTC of more than 500 msecond were four independent correlates of methanol toxicity severity measured with arterial blood PH on arterial blood gas measurements, with p values and odds ratios of < 0.001 (12.386), 0.012 (5.981), 0.018(2.262) and 0.001(3.247), respectively.

Conclusion: Electrocardiographic changes during methanol intoxication are remarkable and correlate well with the severity of poisoning. Myocardial infarction was an egregious yet concerningly common finding in this sample, which need to be ruled out in methanol toxicity.

Background

Methanol is an odorless alcohol with industrial application especially in solvents[1–3]. Most intoxication occurs incidentally by children and rarely as a suicidal attempt. The real toxic material is formic acid, which is a metabolite of methanol in the human body, has at least half time around 30 hours [3]. The slow rate of metabolism of formic acid is the main cause of delayed presentation of methanol toxicity [4]. Clinical findings are blindness, renal shut down, brain damage and finally death if left untreated [2, 3]. Treatment often includes dialysis and ethanol or fomepizole [2]. The outbreaks of methanol toxicity, defined as 3 cases presenting within 72 hours, have been increasingly occurring in recent years [4]. These are possibly due to inappropriate distill or fermentation of alcoholic beverages [5]. Common and novel misconception about the protective and therapeutic role of alcohol consumption for COVID-19 has unfortunately been contributing to this public health problem in Iran. As a result, and due to the forbidden status of alcohol in Iran, availability of homemade alcohol, sometimes contaminated with methanol has

increased which has led to the increased rates of methanol toxicity [6, 7]. After first half of March 2020, Shiraz University of Medical Sciences (SUMS) faced an outbreak of methanol toxicity, which was roughly concomitant with Covid-19 pandemic starting days, however, it nearly faded in second decade of April. Reported numbers with the resultant mortality and morbidity were shockingly high and unheard of in the society and among the medical professionals.

Cardiology service was involved with the care of these patients and was able to collect valuable data about their management and their ECG findings. To date, Zardasht Jaff who reported published the issue on nine patients with methanol toxicity in 2014 and Sanaei-Zade on 42 in 2013 were the studies with the largest sample sizes analyzing the ECG findings attributed to methanol toxicity [8, 9]. As such, this will be the largest study reporting on ECG findings resulted from methanol toxicity.

The goal of this research is to describe the most common ECG findings among patients with methanol toxicity and their association with severity of intoxication.

Method

This is a cross sectional study of 356 patients, who presented with methanol intoxication and were referred to Shiraz University of Medical Science tertiary Hospitals (Namazi and Faghihi) in March and April 2020. The data were collected by a cardiologist from the available charts. The data included demographic characteristics, history, physical examination findings, lab data, and ECG. Then the ECGs reviewed reported by two cardiologists.

History and clinical data include: chronicity of alcohol usage, use of other substances, cardiac and non-cardiac comorbidities, blindness, altered level of consciousness, and death and GCSS (Glasgow Coma Score Scale) for altered level of consciousness. Gathered Laboratory variables were: arterial blood gas measurements, renal function measures, electrolytes and blood sugar.

Following ECG parameters are reported: some basic interpretations (rhythm, rate, axis, hypertrophy and enlargement), interesting relatively new findings in methanol toxicity (ST elevation myocardial infarction and atrioventricular conductance disturbances), repolarization variants (J elevation, early repolarization [10], Brugada pattern [11], U wave, QTc prolongation, QT dispersion, the slope of terminal part of T wave (TTerm SL) [12] and Osborn wave [13]) and depolarization abnormalities (Bundle Branch Block, low voltage QRS, poor R wave progression and fragmented QRS [14]).

The focus of this article is on ECG findings in this unexpectedly large population of patients with methanol toxicity. The PH less than seven named severe acidosis and used as an index of severity for methanol toxicity. The association between acidemia and ECG findings were studied using univariate and multiple variables logistic regression model.

Statistical Analysis

Statistical Package for the Social Sciences Version 21.0 (SPSS Inc., Chicago, IL, USA) was used to analyze the data. Frequency (%) and mean ± standard deviation were used as descriptive indices. Chi-square test was used to assess the relationships between PH and ECG variables in methanol toxicity. Also, odds ratio (OR) and corresponding confidence interval (95% CI) was calculated by univariate logistic regression. To determine the independent relationship between PH and ECG variables, multiple logistic regression was done. P values less than 0.05 were considered statistically significant.

Results

Of the 356 patients, 328 (89.9%) were male and male/female ratio was 9.2. The mean age was 32.76±10.61 with range between 15–72 years old. The proportion of people who used alcohol regularly, at least once every week, was 44.7% and as such, more than half of patients had used alcohol infrequently or for the first time. Concurrent use of the others substances was present in 9.5% of the sample with opium being the most common concurrently used substance. Comorbidities was present in 12% of the patients (cardiac in 6.5% and non-cardiac in 5.6%). The mortality rate in our academic and well experienced centers in managing arrhythmia and other cardiac complications reached 16.6% (59 people). The most common clinical presentation was blindness at 251 (70.5%). The rhythm was sinus in 95.8% and only 4.2% were found to have other rhythms such as atrial fibrillation and low atrial rhythm (Table 1).

Table 1
Clinical variables and ECG findings among methanol toxicity

		Frequency	Percent
Alcohol dependency	Yes	142	39.9
	No	214	60.1
Other substance abuse	Yes	32	9.0
	No	324	91.0
Comorbidity	No	313	87.9
	Cardiac	23	6.5
	Non-cardiac	20	5.6
Decreased visual acuity	Yes	251	70.5
	No	105	29.5
Death	Yes	59	16.6
	No	297	83.4
Renal failure	Yes	137	38.5
	No	219	61.5
GCSS	GCSS 15	252	72.6
	GCSS 3	48	13.8
	GCSS 4–14	47	13.5
Rhythm	Sinus	341	98.0
	Non-sinus	7	2.0
Rate	Normal	251	71.3
	> 100	89	25.3
	< 60	12	3.4
Axis	Normal	296	83.5
	Right	36	10.1
	Left	19	5.3
	Extreme	4	1.1

BBB = bundle branch block, STEMI = ST segment elevation myocardial infarction, AVB = atrioventricular conduction block,

		Frequency	Percent
Hypertrophy and enlargement	No	307	88.5
	RV	9	2.6
	RA	8	2.3
	LV	6	1.7
	LA	9	2.6
	Mixed	8	2.3
Infarction	No	328	94.5
	Yes	19	5.5
AVB	No	334	96.5
	First degree	11	3.2
	Third degree	1	0.3
J point elevation	No	102	29.4
	Yes	245	70.6
Brugada pattern	No	329	94.8
	Type 3	3	0.9
	Type 2	3	0.9
	Type 1	12	3.5
Early repolarization	No	179	51.6
	Yes	168	48.4
Osborn wave	No	334	96.3
	Yes	13	3.7
QTc	<=500	278	80.1
	> 500	69	19.9
QTd	< 40	179	51.6
	>=40	168	48.4
Fragmented QRS	No	226	65.3

BBB = bundle branch block, STEMI = ST segment elevation myocardial infarction, AVB = atrioventricular conduction block,

		Frequency	Percent
	Yes	120	33.734.7
BBB	No	317	91.9
	RBBB	24	7.0
	LBBB	2	0.6
	IVCD	2	0.6
U wave	No	134	38.7
	Yes	212	61.3
Poor R progression	No	321	93.0
	Yes	14	7.0
Low voltage	No	330	95.7
	Yes	15	4.3
BBB = bundle branch block, STEMI = ST segment elevation myocardial infarction, AVB = atrioventricular conduction block,			

In univariate analysis, the patients with QTc more than 500 had more serious acidosis (OR = 3.84;95% CI:2.126–6.922). This more acidotic PH was seen in QTD more than 40 (OR = 1.74;95% CI:1.011–2.995), Atrioventricular block (OR = 5.121;95% CI: 2.077–12.622), sinus tachycardia (OR = 2.032;95%CI:1.136–3.634), Brugada pattern (OR = 2.475;95%CI: 1.044–5.869), ST elevation Myocardial Infarction (OR = 9.745 ;3.507–27.081), and Bundle Branch Block (OR = 2.246 ,95% CI:1.061–4.754). Also, there were no association between severe acidosis with T slope, J elevation, poor R wave progression and low voltage QRS. (Table 2)

In multiple logistic regression, the association between severe acidosis (PH < 7) with QTc > 500 (OR = 3.247, CI = 95%;1.605–6.569), Atrioventricular block (OR = 5.981; CI 95%:1.476–24.227), sinus tachycardia (OR = 2.262; CI 95%;1.152–4.442), and ST elevation myocardial infarction (OR = 12.386; CI 95%;3.681–41.682) were statistically significant. (Table 2)

Discussion

A total number of 356 patients were included in this study and most of the subjects were men, which can be explained by the cultural background and related social stigma of alcohol usage for women in Iran.

Compared to previous outbreaks [15, 16], the age distribution of the population was wider and included teenagers as well as the senior patients, sometimes in their 70’s. The involvement of the youths may be a matter of concern for social activists in Iran.

Different mortality rates have been reported for methanol intoxication, mostly because of definitions. Taiwan nationwide survey showed 40% long term mortality [17], while a study from UK reported a rate of 11% [8]. There is another Iranian research with the rate of 40% by Sanaie-Zade [9]. The mortality rate in our series was slightly less than 17%, which seems to be more than comparable articles6 by Zardasht Jaff [8], however, this mortality is in-hospital mortality in a referral center and those who managed on outpatient basis were not included. This mortality and ocular and brain damage rate are in agreement with some previous outbreaks reports [16, 18–20].

Although in previous report from the UK [8] the most common finding was sinus tachycardia, most cases in this study occurred to have normal heart rate; however, the tachycardia proved to be an index of severity in our research and the lesser prevalence may be due to less severe intoxication in our patients. The heart rate above 100 was present in 25.3% of the sample, which was nearly six times as great as bradycardia (rate below 60). That is to say, roughly three quarter of our cases' rate was in normal range.

Although there are few case reports for myocardial infarction in methanol toxicity [19], our survey is the first which could determine the prevalence of this complication (Fig. 1), however, the exact pathophysiologic mechanism yet remains to be explained. We propose following hypotheses: 1) this infarction noted in relatively young patients without usual risk factors for atherosclerosis [20]. 2) severe acidosis cause bleeding tendency due to reduction of fibrinogen level. Sometimes in situ thrombosis may occur, with ongoing disseminated intravascular coagulation and possible myocardial infarction [21]. 3) possible pathophysiologic mechanism may be endothelial dysfunction, a known entity in reduced extracellular PH, such a dysfunction will end in vasodilation however, frustratingly [22]. 4) acidosis causes vasodilatation and therefore spasm cannot be responsible for the occurrence [23]. This warrants further investigation and research.

J point elevation was the most prevalent finding in our survey; therefore, repolarization abnormalities were tried to be categorized as early repolarization, Brugada, QT prolongation syndrome. The only consistently correlated variable with the severity of disease was QTc prolongation more than 500. The QT prolongation was reported in nearly all of the previous studies, as well [3, 24, 25]. However, its significance could not be emphasized due to the lower volume in older reports. Prolongation of repolarization, measured in many ways, is a hallmark of electrical instability and predictor of cardiac arrest and sudden cardiac death. QTc prolongation is the most commonly used indicator, however, prolongation less than 500 msec. may be interpreted doubtfully. Accordingly, we approached to values above 500 as an independent marker of severity [26, 27].

We noted two type 1 Brugada ECG pattern in two brain-dead patients as terminal event before their arrest which bears similarity with the pattern in some head injured patients before their death in Neurosurgery Intensive care unit, during Propofol infusion [28, 29].

The best independent ECG indicators of methanol toxicity severity were QTc > 500 and heart rate more than 100. Interestingly, severe poisoning was strongly associated with myocardial infarction and atrioventricular block in our survey. (Table 2)

Table 2. Association between PH and ECG variables in methanol toxicity with univariate and multiple logistic regression.

		PH		P-value	Odds ratio (95% CI) Univariate	P-value	Odds ratio (95% CI) Multiple	P-value
		> 7	<=7					
QTC	< 500	233 (85.3)	40 (14.7)	< 0.001	1	-	1	-
	>=500	41 (60.3)	27 (39.7)		3.836 (2.126–6.922)	< 0.001	3.247 (1.605–6.569)	0.001
QT dispersion	< 40	148 (84.6)	27 (15.4)	0.044	1	-	1	-
	>=40	126 (75.9)	40 (24.1)		1.740 (1.011–2.995)	0.046	1.177 (0.620–2.237)	0.618
T slope	< 69	184 (81.1)	43 (18.9)	0.700	1	-	1	-
	>=70	96 (79.3)	25 (20.70		1.114 (0.642–1.934)	0.700	1.291 (0.656–2.543)	0.460
AVB	No	270 (82.3)	58 (17.7)	< 0.001	1	-	1	-
	Yes	10 (47.6)	11 (52.4)		5.121 (2.077–12.622)	< 0.001	5.981 (1.476–24.227)	0.012
Rate	60–100	208 (84.2)	39 (15.8)	0.026	1	-	1	-
	< 59	8 (66.7)	4 (33.3)		2.667 (0.766–9.289)	0.123	1.634 (0.328–8.148)	0.549
	> 100	63 (72.4)	24 (27.6)		2.032 (1.136–3.634)	0.017	2.262 (1.152–4.442)	0.018
Brugada	No	264 (81.5)	60 (18.5)	0.034	1	-	1	-
	Yes	16 (64.0)	9 (36.0)		2.475 (1.044–5.869)	0.04	3.190 (0.979–10.386)	0.054
J elevation	No	85 (85.0)	15 (15.0)	0.164	1	-	1	-
	Yes	189 (78.4)	52 (21.6)		1.599 (0.831–2.924)	0.166	1.128 (0.526–2.418)	0.757
STEMI*	No	268	57	<	1	-	1	-

		(83.0)	(18.2)	0.001				
	Yes	24 (66.7)	12 (33.3)		9.745 (3.507–27.081)	< 0.001	12.386 (3.681–41.682)	< 0.001
BBB*	No	256 (81.8)	57 (18.2)	0.031	1	-	1	-
	Yes	24 (66.7)	12 (33.3)		2.246 (1.061–4.754)	0.035	2.316 (0.857–6.259)	0.098
poor progression	No	256 (81.3)	59 (18.7)	0.083	1	-	1	-
	Yes	16 (66.7)	8 (33.3)		2.139 (0.887–5.308)	0.090	2.549 (0.936–6.937)	0.067
low voltage	No	262 (80.6)	63 (19.4)	0.398	1	-	1	-
	Yes	10 (71.4)	4 (28.4)		1.663 (0.505–5.477)	0.403	1.905 (0.489–7.418)	0.353

*BBB=bundle branch block, STEMI=ST segment elevation myocardial infarction, AVB=atrioventricular conduction block, P value less than 0.05 considered significant

Limitation

The design of the research is cross sectional which suffers lack of long-term insight. Our diagnosis on myocardial infarction is based on ECG finding, evolutionary changes and enzyme rising, however it lacks coronary angiography and cardiac MRI.

Conclusion

This cross-sectional survey of nearly 400 patients, who were admitted due to methanol toxicity, studied the most common ECG findings and their association with PH as a marker of methanol intoxication severity. Myocardial infarction, AVB and sinus tachycardia and QT longer than 500 were four independent markers of severity.

Abbreviations

COVID-19: Coronavirus; SUMS: Shiraz University of Medical Sciences; ECG: electrocardiogram, BBB: bundle branch block; STEMI: ST segment elevation myocardial infarction, AVB: atrioventricular conduction block; msecond: millisecond; UK: United Kingdom; TTerm SL: slop of terminal part of T wave; GCSS: Glasgow Coma Score Scale; QTc: corrected QT

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the ethics committee of Shiraz University of Medical Sciences (Ir.SUMS.REC.1399.059). There were some problems with literacy, visual acuity and understanding of participation in data gathering, accordingly we talk to everyone in best simple way and then they sign the written informed consent. If the patient was under legal age, has visual impairment or unlettered, the parents or guardians included in explanation session and they sign instead. However, any participant is included only if the consent is existed and the ethical committee are aware of the situation.

Consent for publication

Not Applicable.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

MHN, STH, AA contributed in analyzed the data, and interpreted the results, wrote the manuscript drafting. MP, ShSB contributed in interpretation the results and designed the study. VRO, ZKh, JR, MRK, FKHSh, PK contributed in interpretation the results wrote the manuscript drafting. All authors have read and approved the manuscript.

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Figures

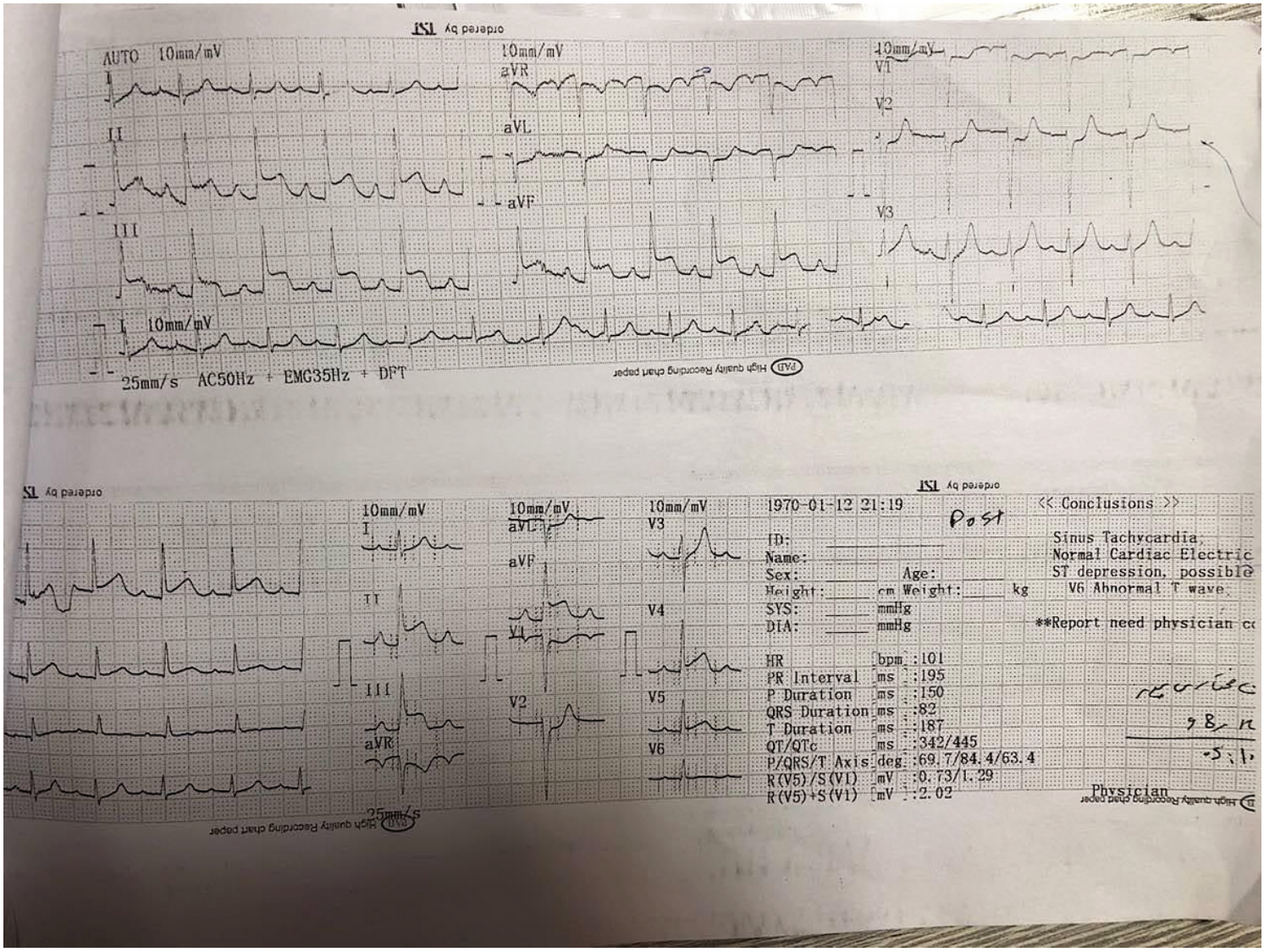

Figure 1

A 33 years old man developed chest pain and cardiac arrest few minutes after this ECG