Original article

The correlation between blood alcohol concentration and biological fluids in corpeses of unnatural death

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Objective To compare the alcohol concentration in blood with that in biological fluids in order to use the latter for evidence in the forensic process of equity when blood cannot be collected from corpses.

Material and method Femoral blood, heart blood, urine, vitreous humor and synovial fluid were collected from 53 corpses of people who died unnaturally and were associated with alcohol consumption. An autopsy and analysis of alcohol were carried our by GC-Headspace at the Forensic Department, Faculty of Medicine, Chiang Mai University. All corpses had been dead from within 2 hours after alcohol consumption, without treatment, decomposition or drowning. Mean and standard deviation were applied for analysis.

Result Fifty three corpses were included in this study, according to the set criteria. The ratio of males to females was 12:1 (92%:8%) and the average age 28 years old (range from 18 to 62 years old). The mean number of samples(bracketed below) in heart blood alcohol concentration (HAC), femoral blood alcohol concentration (FAC), vitreous humor alcohol concentration (VAC), urine alcohol concentration (UAC) and synovial fluid alcohol concentration (SAC) was 194 (46), 194 (53), 219 (49), 203 (50) and 201 (34) mg%, respectively, and the highest alcohol concentration in each specimen type was 556, 529, 511, 493 and 364 mg%, respectively. The ratio of alcohol concentration between heart blood, vitreous humor, urine, synovial fluids to femoral blood was 0.99, 1.14, 1.04 and 1.04 to 1.00, respectively.

Conclusion The alcohol concentration in biological fluids was related closely with that in blood from the corpses of people that died at the death scene or within 2 hours after alcohol consumption, without treatment, decomposition or drowning. **Chiang Mai Medical Journal 2015;54(2):65-70.**

keywords: corpses, unnatural death, biological fluid, alcohol concentration

Introduction

Blood alcohol concentration plays an important role in the forensic process of equity, since it helps to prove the causes and occurrences of death, especially in cases of accident related to alcohol consumption. According to the research of Narongchai on deaths from road traffic accidents in Chiang Mai and nearby areas,[1] 65% of the corpses from people who died unnaturally had a blood alcohol concentration (BAC), and 53.6% of deaths

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were from road traffic accidents[2,3]. However, Pholaeimaeg S *et al* found that in Thonburi, Bangkok, 39.6% of the corpses from traffic accidents had BAC[4].

BAC is used as evidence to identify whether drunken driving had caused a death. According to the Road Traffic Act issued by the Ministry of Interior, it is illegal to drive a vehicle with more than 50 mg% of alcohol in the blood[5,6], as that level reduces consciousness and body movement and leads to a higher rate of accidents. Furthermore, ascertaining the alcohol level in blood is useful in homicide and suicide cases because BAC can help to estimate whether a drinker was able to walk or move freely. This includes cases in which drinkers have taken other drugs with alcohol, which causes a higher death rate. Therefore, checking for BAC is necessary for every case of unnatural death. However, some conditions, especially of treatment, decomposition and drowning, cannot be determined by BAC. Then, biological fluids have to be used instead of blood in decomposed cases, since these corpses have higher BAC, due to the growth of bacteria and fermentation in the intestines and other parts of the body. The organisms use blood as food before synthesizing many kinds of alcohol, including edible alcohol (ethanol)[7]. Drowned corpses have a lower BAC because they absorb a lot of water, similar to corpses of people that were treated and cured before dying. They also have a lower BAC since many kinds of fluids had been put into their body.

A previous study showed that BAC related to biological fluids as follows: vitreous humor alcohol concentration (VAC)=1:0.77 (the early alcoholic absorption phase), 1:1.12 (the late alcoholic absorption phase) and BAC: urine alcohol concentration (UAC)=1:1.29[8].

Alcohol concentration in biological fluids might be different in Thais, as BAC is in accordance with race, lifestyle and kinds of liquor. Therefore, a standard for Thai people and fundamental knowledge of alcohol concentration in biological fluids should have been studied for corpses that could not be analyzed from blood, such as those treated, decomposed or drowned.

Heart blood alcohol concentration (HAC), femoral blood alcohol concentration (FAC), VAC, UAC and synovial alcohol concentration (SAC) could be used to determine the amount of alcohol taken, and as a standard amount of alcohol in blood especially collected from a peripheral vessel, such as the cubital fossa or inguinal region in corpses resulting from sudden cardiac death within 2 hours after alcohol consumption (the alcoholic absorption phase), without treatment before death and not yet decomposed. According to the research of Riensuwan[9], 76% of road traffic accident deaths occurred in people aged from 21 to 40 years old, and 59% had a BAC of over 100 mg%. Furthermore, according to the research of Narongchai[3], 99.8% of victims were men, with 60% of them aged from 20 to 40 years old, and 70.7% had a BAC of over 100 mg%.

Material and Method

All 53 corpses in this study were whole bodies of people suffering unnatural death, sudden cardiac death (within 2 hours), drowning and no prior treatment. The author carried out autopsies to ascertain the causes and manner of death at the Forensic Medicine Department, Chiang Mai University. The samples of femoral vessel blood, heart blood, vitreous humor, urine and synovial fluid were taken from the corpses by using the sterile technique and preserved with sodium fluoride (NaF) anticoagulant at 4 ^{o}C in a refrigerator. NaF functioned as an enzymatic inhibitor, which prevented production of ethanol during the time of autopsy and laboratory analysis. All of the samples were analyzed daily by GC-Headspace in order to detect the alcohol concentration. The alcohol concentrations of all samples were in the absorption phase of alcohol metabolism. The alcohol concentration level in blood and biological fluids was presented in mean value, with the ratio of each sample compared to the FAC.

Result

Fifty three corpse samples were selected from unnatural deaths and an alcohol concentration was detected in all of them. The male to female ratio was 92%:8% or 12:1. The age range was from 18 to 62 years, with a mean age of 28 years. The most common age range was from 20 to 40 years (77.4%). Forty three

of the 53 corpses (81.13%) had a BAC (FAC) of over 100 mg%. The BAC (FAC) ranged from 11 to 556 mg%. The most common range of BAC or FAC was from 100 to 150 mg% (22.6%), with the FAC being more than 300 mg% in 15.1% of the corpses. The average alcohol concentrations of HAC, FAC, VAC, UAC and SAC were 194, 194, 219, 203 and 201 mg%, respectively. The relative ratio of HAC, VAC, UAC and SAC to FAC was 0.99, 1.14, 1.04 and 1.04 to 1.00, respectively (Table 2). The ratios of HAC, VAC, UAC and SAC to FAC at different levels of FAC (BAC) are shown as follows:

Discussion

The Thai people involved in this study were seen to drink too much alcohol[1-3]. The alcohol concentration in the body was very high, which decreased the ability of the nervous system and caused violent accidents. Although FAC (BAC) is usually the preferred sample for accurately detecting alcohol in corpses, other samples are considered important when relating to pre death conditions. The alcohol concentration in a variety of postmortem samples is very important for gaining more information, especially in cases when the BAC cannot be collected or has been interfered with by conditions such as decomposition, drowning, etc. According to the study of Supamonkol[10] the BAC collected from the cubital or femoral vein relates best to the manifestation of alcohol toxicity. However, the HAC may be higher than the FAC when diffuse absorption occurs from the stomach. This study showed that the HAC is related closely to the FAC (BAC) at about 0.99.

The ratio of VAC to BAC (FAC) was 1.13 and 1.12 from a previous study[8] and this one, respectively. The VAC is used to obtain the actual BAC (FAC) in corpses that are decomposed, or with severe blood loss from trauma, drowning, etc[11-13] Decomposed corpses have a higher alcohol concentration than normal ones due to the microbial synthesis of ethanol. However, corpses found drowned in water have a lower alcohol concentration than normal ones, owing to the dilution of body fluid. [11-13]

The ratio of UAC to BAC (FAC) has been analyzed from many researches[14] and it can determine the status of alcohol absorption at the time of death[15-17]. When it is equal or 1:1, it shows the absorption phase of alcohol ingestion at the time of death or initial drinking, and incomplete absorption from the stomach to blood circulation, whereas, when it is 1.29:1, it is in the stage of complete absorption or elimination phase[17]. However, urine is a common specimen taken from corpses for analyzing alcohol because its contamination from microbial organisms is less likely. This study showed that the ratio of UAC to BAC (FAC) is 1.04:1, which is no different from previous studies. Therefore, it is very useful and informs accurately on the status of alcohol ingestion at the time of death.

The ratio of SAC to BAC (FAC) has not been studied clearly, but this study shows that there is a rather good relationship between these concentrations, especially in an alcohol absorption phase, in which the ratio is nearly the same at 1.03:1. Also, if there are many future researches on this ratio, SAC may be another useful way of determining the FAC

Table 1. The ratios of HAC, VAC, UAC and SAC to FAC in the difference alcohol concentration

The ratios of alcohol in Biological fluids	The difference alcohol concentration (mg%)					
	<50	**51-100**	**101-150**	**151-200**	**201-300**	**>301**
HAC: FAC	0.86	0.96	1.13	0.90	1.01	1.01
VAC: FAC	1.40	1.05	1.09	1.03	1.17	1.02
UAC: FAC	1.61	1.13	1.06	1.02	0.98	1.07
SAC: FAC	1.91	1.13	0.94	0.88	0.78	0.98

Table 2. General information, alcohol concentration in blood and biological fluids and ratios

No	Sex	Age	HAC	FAC	VAC	UAC	SAC	H :F	V:F	U:F	S:F
1	M	22	ND	157	195	128	136	ND	1.24	0.82	0.87
2	M	31	ND	232	273	223	185	ND	1.18	0.96	0.8
3	M	62	ND	130	134	133	113	ND	1.03	1.02	0.87
4	M	38	429	433	365	440	480	0.99	0.84	1.02	1.11
5	M	31	28	32	53	55	61	0.88	1.66	1.72	1.91
6	M	20	184	220	255	203	ND	0.84	1.16	0.92	ND
7	M	20	191	107	136	88	71	1.78	1.27	0.82	0.66
8	M	22	148	104	130	73	47	1.42	1.25	0.7	0.45
9	M	28	281	290	347	284	210	0.97	1.2	0.98	0.72
10	F	42	370	340	463	423	355	1.09	1.36	1.24	1.04
11	M	27	ND	242	287	234	177	ND	1.18	0.97	0.73
12	M	23	62	82	ND	89	70	0.76	ND	1.08	0.85
13	M	20	232	245	327	208	211	0.95	1.33	0.85	0.86
14	M	21	76	72	88	80	92	1.06	1.22	1.11	1.28
15	M	41	405	469	505	477	449	0.86	1.08	1.02	0.96
16	F	50	556	529	511	493	364	1.05	0.97	0.93	0.69
17	M	20	161	171	ND	134	150	0.94	ND	0.78	0.88
18	M	42	302	271	306	214	213	1.11	1.13	0.79	0.79
19	M	24	180	179	171	207	137	1	0.96	1.16	0.77
20	M	35	211	201	249	189	ND	1.05	1.24	0.94	ND
21	M	19	159	168	197	132	107	0.95	1.17	0.79	0.64
22	M	20	ND	231	276	204	191	ND	1.19	0.88	0.83
23	M	19	246	207	265	194	83	1.19	1.28	0.94	0.4
24	M	42	347	390	513	367	459	0.89	1.32	0.94	1.18
25	M	22	213	279	360	253	ND	0.76	1.29	0.91	ND
26	M	51	189	237	254	234	268	0.8	1.07	0.99	1.13
27	M	30	174	182	222	175	ND	0.96	1.22	0.96	ND
28	M	40	82	104	107	124	183	0.79	1.03	1.19	1.76
29	M	45	244	268	288	282	305	0.91	1.07	1.05	1.13
30	M	20	ND	88	145	91	85	ND	1.65	1.03	0.96
31	M	20	150	159	ND	157	156	0.94	ND	0.99	0.98
32	M	26	383	328	290	315	318	1.17	0.88	0.96	0.97
33	M	30	122	134	134	173	ND	0.91	1.00	1.29	ND
34	M	24	90	90	102	112	ND	1.00	1.13	1.24	ND
35	M	25	147	171	166	173	ND	0.86	0.97	1.01	ND
36	M	25	168	188	197	208	ND	0.89	1.05	1.11	ND
37	M	56	110	118	112	122	128	0.93	0.95	1.03	1.08
38	M	28	9	11	17	19	ND	0.82	1.54	1.73	ND
39	M	29	56	55	39	35	ND	1.02	0.71	0.64	ND
40	F	25	120	136	127	158	123	0.88	0.93	1.16	0.98
41	M	20	83	103	ND	146	ND	0.81	ND	1.42	ND
42	M	20	160	119	91	93	ND	1.34	0.76	0.78	ND
43	M	20	ND	74	58	40	ND	ND	0.78	0.54	ND
44	M	20	34	39	39	ND	ND	0.87	1.00	1.39	ND
45	M	20	213	204	208	267	ND	1.04	1.02	1.31	ND
46	M	26	118	159	116	207	ND	0.74	0.73	1.3	ND
47	M	21	340	387	371	434	420	0.88	0.96	1.12	1.08
48	M	38	124	137	198	ND	223	0.9	1.44	1.78	1.63
49	M	18	108	124	108	144	ND	0.87	0.87	1.16	ND
50	M	20	151	139	135	ND	133	1.09	0.97	ND	0.96

Table 2. Continued

No	Sex	Age	HAC	FAC	VAC	UAC	SAC	H :F	V:F	U:F	S:F
51	M	21	98	100	114	156	127	0.98	1.14	1.56	1.27
52	M	20	435	415	429	485	ND	1.05	1.03	1.17	ND
53	M	21	240	239	243	279	ND	1.00	1.02	1.17	ND
No	53	53	46	53	48	50	34	ND	ND	ND	ND
X		28.30	194.10	194.13	218.69	203.08	200.88	0.98	1.11	1.06	0.98
S.D.		11.19	120.48	117.12	131.52	122.20	126.26	0.18	0.21	0.26	0.33
ratio			0.995	1.00	1.14	1.04	1.00	0.995	1.14	1.04	1.00

(BAC) at the time of death in corpses decomposed, drowned, etc., because synovial fluid is not contaminated by organisms or dilution.

Alcohol concentration in blood is related to that in biological fluids by relying on the period of time after drinking, absorption metabolism, and alcohol scattered in the body. The alcohol concentration in biological fluids instead of that in blood could be used for assessing toxicity in legislation, especially in cases that have denatured blood such as decomposed, drowned and treated corpses. Alcohol concentration in biological fluids is quantitatively detected from parts of the body, and it substitutes BAC in cases of denatured blood. The ratio of alcohol in blood to that in biological fluids could be used from this study as a standard in the result of BAC at the time of death.

References

1. **Narongchai S, Narongchai P**. Study of blood alcohol concentration in corpses due to traffic accidence (during 1985-1989) Forensic Sci 1990;19: 79-86.
2. **Narongchai P, Narongchai S, Thampituk S**. The incidence of drug abuse in unnatural deaths in northern Thailand. J Med Assoc Thai 2007;90:137-43.
3. **Narongchai S, Narongchai P**. The prevalence of detectable blood alcohol concentration among unnatural deaths in northern Thailand. J Med Assoc Thai 2006;89:809-13.
4. **Pholaeimaeg S, Riensuwan M, Sasithornthonchai W**. Blood alcohol concentration in corpses of traffic accidence. Forensic Sci 1986;15:71-82.
5. **Law, Ministry of Interior** (Issue No 16) AD. 2537, Government Gazette Book No 11, There No 54 A, 8th December AD. 1994 page No 1-2.
6. **Road Traffic Act** (Issue No 4) AD. 2535, Government Gazette Book No 109 There No 39, 6th April AD. 1992.
7. **Christopoulos G, Kirch BR, Gearien JE**. Determination of ethanol in fresh and putrefied post mortem tissues. J Chromatogr A 1973;87:455-72.
8. **Chao TC, Lo DS**. Relationship between postmortem blood and vitreous humor ethanol. Am J Forensic Med Pathol 1993;14:303-8.
9. **Riensuwan M, Sasithornthonchai W**. Blood alcohol concentration in patients of traffic accidence. Forensic Sci 1993;22:19-27.
10. **Supamongkol A**. The comparison of blood alcohol concentration in different parts of corpses. Forensic Sci 1996;25:41-50.
11. **Kuhlman Jr JJ, Levine B, Smith ML, Hordinsky JR**. Toxicological findings in Federal Aviation Administration general aviation accidents. J Forensic Sci 1991;36:1121-8.
12. **Canfield DV, Kupiec T, Huffine E.** Postmortem alcohol production in fatal aircraft accidents. J Forensic Sci 1993;38:914-7.
13. **Mayes R, Levine B, Smith ML, et al**. Toxicologic findings in USS Iowa disaster. Forensic Sci 1992;37:1352-7.
14. **Jones AW**. Reference limits for urine/blood ratios of ethanol in two successive voids from drinking drivers. J Anal Toxicol 2002;26:333-9.
15. **Ito A, Moriya F, Ishizu H.** Estimating the time between drinking and death from tissue distribution patterns of ethanol. Acta Med Okayama 1998;52: 1-8.
16. **Jones AW, Holmgren P.** Urine/blood ratios of ethanol in deaths attributed to acute alcohol poisoning and chronic alcoholism. Forensic Sci Int 2003;135:206-12.
17. **Levine B, Smialek JE**. Status of alcohol absorption in drinking drivers killed in traffic accidents. J Forensic Sci 2000;45:3-6.

การศึกษาความเข้มข้นของแอลกอฮอล์ในเลือดและสารคัดหลั่งทางชีวภาพในผู้ที่เสียชีวิตโดยผิดธรรมชาติ

ไพฑูรย์ ณรงค์ชัย และ สิริพันธ์ ณรงค์ชัย
ภาควิชานิติเวชศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

วัตถุประสงค์ เพื่อเปรียบเทียบความเข้มข้นของแอลกอฮอล์ในเลือดกับสารคัดหลั่งทางชีวภาพ และเพื่อนำมาใช้เป็นพยานหลักฐานทางนิติเวชศาสตร์โดยเฉพาะในศพที่เน่า จมน้ำ เสียเลือดมากและศพที่ถูกทำลาย

วัสดุและวิธีการ เลือดที่เจาะจากหลอดเลือดที่ขาหนีบ หัวใจ น้ำในลูกตา ปัสสาวะและน้ำในข้อที่เจาะจากศพที่ถูกคัดตามข้อบ่งชี้คือศพเหล่านี้ไม่ได้มีการรักษามาก่อน ไม่เน่า ไม่จมน้ำ จำนวน 50 ศพที่มีประวัติดื่มสุราและเสียชีวิตภายหลังดื่มสุราไม่เกิน 2 ชั่วโมง ทำการตรวจวิเคราะห์ระดับแอลกอฮอล์ด้วยเครื่อง GC-Head-space ที่โรงพยาบาลมหาราชนครเชียงใหม่ สำหรับการวิเคราะห์ทางสถิติใช้ค่าเฉลี่ยและค่าเบี่ยงเบนมาตรฐานมาทำการวิเคราะห์

ผลการศึกษา ศพจำนวน 53 ศพคิดเป็นจำนวนร้อยละ 4 ของจำนวนศพทั้งหมดที่อยู่ในเกณฑ์ข้อบ่งชี้ อัตราส่วนระหว่างเพศชายต่อเพศหญิง 49 (ร้อยละ 92):4 (ร้อยละ 8) อายุเฉลี่ย 29 ปี (อยู่ในช่วง 18-62 ปี) ความเข้มข้นของแอลกอฮอล์ (จำนวนศพ) ในเลือดหัวใจ หลอดเลือดที่ขาหนีบ น้ำในลูกตา ปัสสาวะและน้ำในข้อ มีปริมาณ 194 (46), 194 (53), 219 (49), 203 (50) และ 201 (34) มิลลิกรัมเปอร์เซนต์ ตามลำดับ และความเข้มข้นที่สูงที่สุดในแต่ละแห่งคือ 556, 529, 511, 493 และ 364 มิลลิกรัมเปอร์เซนต์ ตามลำดับ อัตราส่วนของแอลกอฮอล์ในเลือดระหว่างหัวใจกับ น้ำในลูกตา ปัสสาวะ น้ำในข้อและเปรียบเทียบกับในเลือดจากหลอดเลือดที่ขาหนีบ คือ 1.00, 1.13, 1.04 และ 1.03 ตามลำดับ

สรุป ความเข้มข้นของแอลกอฮอล์ในสารคัดหลั่งมีความสัมพันธ์อย่างใกล้ชิดกันกับในเลือดโดยเฉพาะในศพที่เสียชีวิตภายใน 2 ชั่วโมงหลังจากการดื่มสุราและไม่ได้มีการรักษามาก่อน ไม่เน่า ไม่จมน้ำ **2558;54(2):65-70.**

คำสำคัญ: ความเข้มข้นของแอลกอฮอล์ในเลือด ในสารคัดหลั่ง ศพที่เสียชีวิตโดยผิดธรรมชาติ