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Application of electrolyte analysis of pleural effusion to diagnosis of drowning

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ABSTRACT

We measured concentrations of sodium (Na), chloride (Cl), calcium (Ca), and magnesium (Mg) in pleural effusion from forensic autopsy cases to examine whether they were useful for a diagnosis of drowning. We analyzed a total of 51 cases (15 seawater drowning, 10 freshwater drowning, and 26 non-drowning), and determined the following reference values. If the concentration of Na or Cl is under 65 mEq/l, a diagnosis of freshwater drowning can be made. If the concentration of Na is higher than 175 mEq/l, or that of Cl is higher than 155 mEq/l, or that of Ca is higher than 16 mg/dl, or that of Mg is higher than 15 mg/dl, a diagnosis of seawater drowning can be made. We recommend that pleural effusion from the left and the right thoracic cavities should be collected and analyzed separately because large differences may be observed between each side in the case of drowning. If one side corresponds to the reference value for seawater or freshwater drowning and the other side does not, a diagnosis of drowning can still be made according to the obtained value.

1. Introduction

Drowning is diagnosed mainly from macroscopic findings, such as froth in the air passage, or drowned lungs if the postmortem interval is within a few days and decomposition is not observed [1,2]. If the postmortem interval exceeds this period, the above mentioned findings are no longer observed. Instead, extensive pleural effusion is often observed in the thoracic cavity, and this finding is applied to the diagnosis of drowning since victims of drowning are assumed to have inhaled a large amount of water and the water exudes into the thoracic cavity due to postmortem changes [3–9].

On the other hand, extensive pleural effusion is also observed in the thoracic cavity if cardiac or pulmonary disease existed before death, or severe pulmonary edema developed in the agonal period regardless of the cause of death and fluid exuded into the thoracic cavities due to postmortem changes. It is therefore difficult to diagnose drowning from extensive pleural effusion alone. Moreover, it is also often very difficult to distinguish between drowning in freshwater (freshwater drowning) and drowning in the sea (seawater drowning) just from the extent and appearance of pleural effusion.

If drowning is suspected during the forensic autopsies, parts of the lungs, spleen, liver, and kidneys are collected and dissolved in strong acids or enzymes to detect diatoms contained in the water inhaled when drowning. The diatom species are then identified using a light microscope, and the site of drowning is estimated from the ecology of the diatom [10–22]. However, if the victim drowned in water containing few diatoms, it is difficult to determine whether the drowning took place in fresh or seawater.

Recently, Usumoto et al. reported that it was valuable for the diagnosis of seawater drowning to measure concentrations of sodium (Na) and chloride (Cl) in pleural effusion [23,24]. They analyzed the means of the electrolytes concentrations of the left and right pleural effusions. However, a large difference can be observed in electrolyte concentration between the two cavities because a large difference is sometimes observed in the volume of pleural effusion between the two cavities. Moreover, calcium (Ca) and magnesium (Mg), besides Na and Cl, are abundant in seawater. Therefore, we collected pleural effusions from the left and the right thoracic cavities separately, and analyzed concentrations of the electrolytes (Na, Cl, Ca, and Mg), respectively, for the cavities.

2. Materials and methods

We selected cadavers with over 10 ml of pleural effusion in the left and right thoracic cavities, respectively, that underwent forensic autopsy between April 2008 and May 2011. Cadavers with thoracic injuries, thoracic hemorrhage or severe decomposition, as well as those where the cause of death could not be determined were excluded from the analysis.

In total, there were 51 cases (27 males and 24 females): 15 seawater drowning, 10 freshwater drowning, and 26 non-drowning (Tables 1–3).

Drowning was diagnosed after confirming several findings, such as froth in the air passage, drowned lungs, a large amount of fluid

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Table 1
Concentrations of electrolytes of pleural effusion in seawater drowning group.

No.		Na (mEq/l)	Cl (mEq/l)	Ca (mg/dl)	Mg (mg/dl)	Volume (ml)	PMI (days)	Age	Sex
1	L	232	303	2.8	23.9	500	10	21	M
	R	215	290	5.3	23.8	810			
2	L	240	252	20.2	54.0	70	4	58	F
	R	216	225	18.8	51.0	330			
3	L	219	250	17.7	49.0	150	10	57	F
	R	224	255	17.1	51.0	200			
4	L	369	404	31.9	81.0	270	19	69	M
	R	354	396	37.2	84.6	300			
5	L	315	342	26.6	80.0	600	6	61	F
	R	229	248	19.3	54.6	500			
6	L	110	118	8.0	26.6	650	45	74	M
	R	188	234	10.0	35.0	750			
7	L	161	214	24.1	34.0	400	60	54	M
	R	126	175	11.9	30.1	250			
8	L	160	139	13.1	20.0	50	1	59	M
	R	156	137	13.3	21.6	100			
9	L	165	277	8.2	31.9	30	30	58	M
	R	148	250	5.8	20.5	120			
10	L	293	313	24.3	67.0	100	2	43	M
	R	286	308	24.1	56.0	170			
11	L	224	268	7.6	38.5	870	30	34	M
	R	225	265	11.0	42.9	1100			
12	L	191	203	16.3	38.5	470	3.5	67	F
	R	148	160	14.8	29.1	370			
13	L	199	209	17.4	46.5	330	1	38	F
	R	186	191	16.8	45.0	250			
14	L	250	275	21.9	54.0	90	2	84	F
	R	252	278	23.0	56.0	60			
15	L	269	312	24.5	67.0	700	11	74	M
	R	249	290	23.1	65.0	700			

L, left; R, right; PMI, postmortem interval; M, male; F, female.

Table 2
Concentrations of electrolytes of pleural effusion in freshwater drowning group.

No.		Na (mEq/l)	Cl (mEq/l)	Ca (mg/dl)	Mg (mg/dl)	Volume (ml)	PMI (days)	Age	Sex
16	L	61	88	0.1	1.3	20	5	65	M
	R	61	84	0.7	3.2	50			
17	L	108	84	8.3	4.9	75	2.5	26	M
	R	106	82	8.5	5.1	50			
18	L	42	50	7.3	5.6	700	23	60	M
	R	46	51	8.2	6.5	920			
19	L	82	77	3.1	5.4	120	5	67	M
	R	51	56	1.8	3.5	400			
20	L	55	73	1.9	4.7	300	6	61	M
	R	65	74	1.3	4.5	350			
21	L	72	64	5.4	2.8	70	1.5	59	M
	R	76	64	5.8	2.9	170			
22	L	64	89	2.9	7.1	390	60	34	F
	R	63	79	2.9	6.7	320			
23	L	68	60	7.8	5.0	150	12	65	F
	R	67	60	8.4	5.1	170			
24	L	52	46	4.2	3.0	240	1.5	28	F
	R	55	48	4.7	3.1	240			
25	L	53	42	4.2	4.1	150	1	71	M
	R	72	54	5.1	4.6	50			

L, left; R, right; PMI, postmortem interval; M, male; F, female.

in the thoracic cavity, detection of diatoms in lung, spleen, and heart blood specimens, as well as the absence of findings indicative of other causes of death. None of the cadavers presented a finding of cardiac or lung diseases which could induce antemortem pleural effusion formation. All drowning cases were accidental or suicidal, and place of drowning was in freshwater or seawater as revealed by police investigation and autopsy findings. There was no drowning in a brackish water area.