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Spleen findings in drowning

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Abstract

A retrospective study of spleen findings in 42 victims of drowning and a comparison group of 42 cases of asphyxiation due to other causes (hanging, ligature strangulation and manual strangulation), that were matched for sex, age, body weight and build, was performed. Significantly smaller spleen weights ($P < 0.05$), spleen weight:body weight ratios ($P < 0.01$) and spleen weight:liver weight ratios ($P < 0.01$) were found in the victims of drowning. The difference in weight was ~ 18%. A significant negative correlation between spleen weight and blood alcohol concentration was found in the study group ($r = -0.44$; $P < 0.01$), but not in the control group. The possibility that the findings are due to a stress reaction caused by hypoxia in the presence of cooling and an influence of alcohol on reflex mechanisms is discussed.

Keywords: Drowning; Spleen; Alcohol

1. Introduction

Reports of a small, blood-depleted, dry spleen as a sign of drowning can be traced back many years in the literature. It was Ssabinsky in 1867 [1] who, in the course of investigations on animals into the formation and incidence of Tardieu's spots following death by asphyxiation, was the first to note contraction and anaemia of the spleen that occurred in parallel with the process of asphyxiation, and contrasted it with the congestion of the other abdominal organs. This was found to occur consistently in asphyxiation due to various causes and in an experiment with carbon monoxide poisoning. In 1903, Reuter [2] found this phenomenon to be associated mainly with drowning; it was observed at autopsy in 58% of drowning victims, but in only 7% of cases of hanging. Finally, Gatti [3] reported results of animal experi-

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ments in 1963, which were later corroborated by autopsy findings in man [4]; his histomorphometric investigations revealed 10–20% lower erythrocyte counts in the spleen after death by drowning or haemorrhage than after death by carbon monoxide poisoning or hanging. Although contrary findings, i.e. enlargement of the spleen, have been reported only by Del Campo and Del Campo [5], this sign has remained controversial. Some specialist textbooks mention anaemia of the spleen as a non-specific sign of asphyxiation, but references to the small, dry spleen as a finding in drowning are rare, especially compared to the situation in older textbooks. The aim of this study was to determine whether this finding is just a non-specific sign of asphyxiation, or whether it can be considered a useful diagnostic sign of drowning.

2. Material and methods

During the period 1980–1990, autopsies were performed at the Institute of Forensic Medicine of the University of Tübingen on a total of 150 drowning victims and 166 persons who had died of asphyxiation due to other causes. Cases with signs of decomposition, severe haemorrhage, obvious disease of the liver or spleen, or in which re-animation had been attempted, were excluded, leaving a total of 69 cases of drowning and 109 cases of other types of asphyxiation for comparison. A control case matched for sex, age (±10 years), weight (±15%), and build (Broca index ±15%) was sought in the comparison group for each of the cases in the drowning group. In this way, two matched groups each containing 42 subjects (18 females and 24 males) were formed (Table 1). All of the drownings had occurred in fresh water. Only cases in which the autopsy report recorded the presence of emphysema aquosum were included, to exclude deaths from immersion other than drowning, which could have confused the situation concerning spleen findings specific to drowning. In the comparison group, there were 23 cases of hanging, 13 of ligature strangulation, five of manual strangulation and one of suffocation by a soft object. A preliminary inspection of this comparison group revealed no significant differences in the parameters investigated in relation to the various causes of death.

Table 1
Details of the two matched groups studied, with mean values (x) and standard deviations

	Drowning victims (n = 42)	Comparison group (n = 42)
Male:female ratio	24:18	24:18
Age (years)	17–83	17–84
	$x = 45.1 \pm 20.2$	$x = 44.2 \pm 20.4$
Weight (kg)	50–100	50–85
	$x = 66.2 \pm 10.7$	$x = 66.1 \pm 8.9$
Broca index	0.71–1.34	0.73–1.25
	$x = 0.99 \pm 0.13$	$x = 0.96 \pm 0.12$

The spleen weight as recorded in the autopsy report was the main parameter of organ size considered. However, the description of the gross features of the spleen was also evaluated, despite the inevitable subjective influences involved. In addition, the blood content of the spleen was evaluated in haematoxylin and eosin stained sections by an experienced pathologist without knowledge of the diagnosis. This was performed as in routine diagnostics without the use of morphometric techniques. The spleen was defined as blood-depleted when there were only a few or no erythrocytes in the sinuses, and as congested when engorgement of the sinuses was seen even at low magnification. The blood content was classed as moderate between these two extremes (Fig. 1).

Finally, a possible influence of alcohol on the findings was investigated, in line with the notion that alcohol intoxication — itself or via the pathological influence on reflex mechanisms that has recently been discussed in connection with bolus death and sudden death in water [6–8] — could accelerate or be superimposed on the process of drowning and thus obscure any possible drowning-specific findings.

The results were subjected to statistical analysis by the sign test, the Wilcoxon matched pair rank test, the chi-square test and correlation analysis.

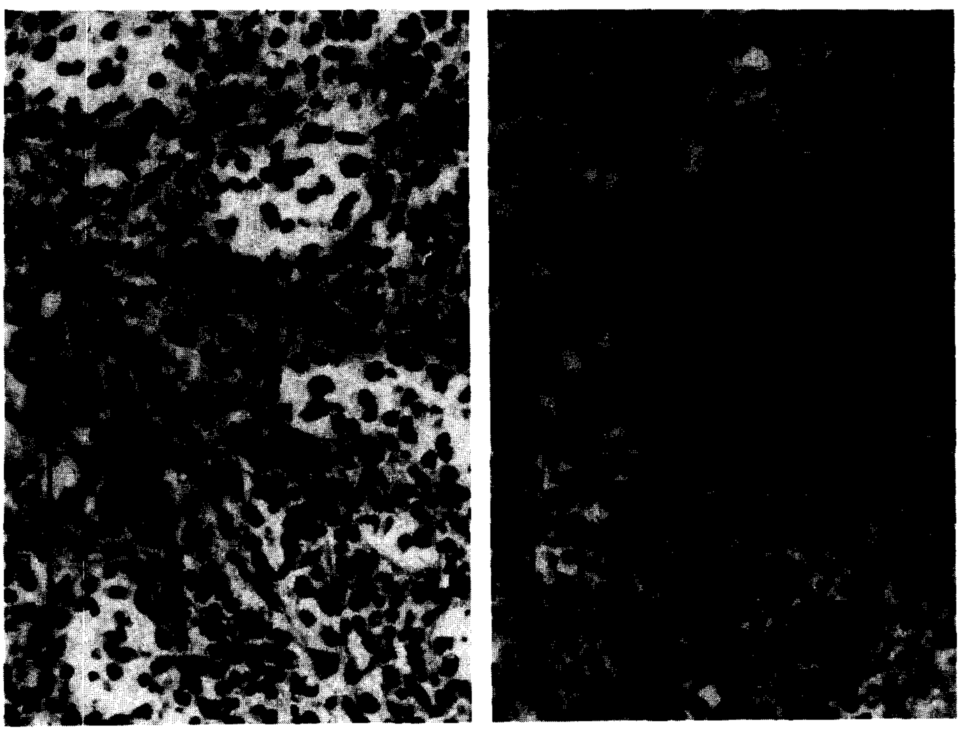

Fig. 1. Examples of specimens defined as blood-depleted (left) and congested (right).

3. Results

No differences in liver weight were found between the two groups, but the spleen weights in the study group (i.e., drowning victims) were significantly lower than in the comparison group ($P < 0.05$). The average difference in weight was ~ 18%. The ratios spleen weight:body weight and spleen weight:liver weight also differed by about the same amount. Since these ratios take into account further influences, the difference here was of a higher level of significance ($P < 0.01$; Table 2).

Fig. 2 shows the distribution of spleen weights in the two groups. The weights in the comparison group follow an almost normal distribution, but in the study group the curve is skewed to the left. The minimal and maximal values, especially the latter, were similar in both groups.

Evaluation of the gross findings recorded in the autopsy reports revealed only minor differences between the two groups. The capsule was described as flaccid in 20 study cases and 15 comparison cases ($P = 0.27$). The cut surface was described as dry in ten study cases and five comparison cases ($P = 0.15$). Congestion was noted in only seven of the study cases but in 13 of the comparison cases ($P = 0.06$).

The histological investigations also revealed no statistically significant differences. Blood depletion was seen only rarely, although it was more common in the study group (seven cases) than in the comparison group (three cases). The blood content of the spleen appeared normal in 18 study cases and 20 comparison cases. The histological evaluation revealed congestion in 11 spleens in each group. Assessment was not possible in the other cases.

Alcohol in the blood was detected in 18 (43%) of the drowning victims, with a concentration range 0.13–3.36 g/kg. By contrast, it was found in only 10 (24%) of the comparison cases, with a concentration range here of 0.19– 2.43 g/kg. A possible correlation between the spleen weight (in the form of the ratio spleen weight:body weight) and the blood alcohol concentration was sought. Although no association was found in the comparison group ($r = -0.13$; $P > 0.05$), a significant correlation was found in the study group, which, surprisingly, proved to be negative: the higher the blood alcohol concentration, the smaller the spleen (Fig. 3) $r = -0.44$; $P < 0.01$.

Table 2
Weights of the spleen and liver, spleen weight:body weight ratio and spleen weight:liver weight ratio (range, mean (x) and standard deviation)

	Drowning victims ($n = 42$)	Comparison group ($n = 42$)	P
Spleen weight (g)	50–320 $x = 141.8 \pm 59.5$	80–330 $x = 173.8 \pm 56.8$	<0.05
Liver weight (g)	1220–2600 $x = 1760.6 \pm 323.9$	1140–2420 $x = 1676.1 \pm 319.4$	>0.05
Spleen weight:body weight (%)	0.073–0.492 $x = 0.214 \pm 0.084$	0.123–0.413 $x = 0.262 \pm 0.071$	<0.01
Spleen weight:liver weight	0.03–0.17 $x = 0.08 \pm 0.03$	0.04–0.19 $x = 0.10 \pm 0.03$	<0.05

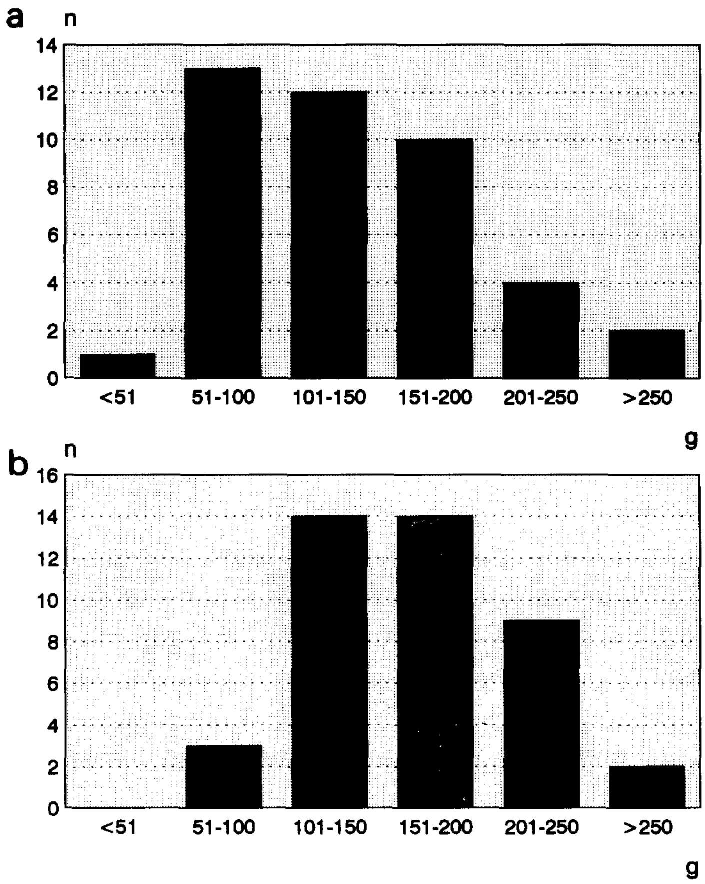

Fig. 2. Distribution of spleen weights in the (a) the study group ($n = 42$) and (b) comparison groups ($n = 42$).

Because of these findings, the influence of alcohol intoxication was studied by investigation of the spleen weight, spleen weight:body weight ratio, and spleen weight:liver weight ratio in the 22 pairs in which neither partner had evidence of alcohol in the blood at the time of death (Table 3). The differences between these smaller groups were found to be smaller than those between the two main groups. The probability value for differences in all three parameters investigated was always close to 0.05. It was just under 0.05 for spleen weight and spleen weight:body weight with the sign test, and spleen weight:liver weight with the Wilcoxon matched pair rank test. It was just over 0.05 for spleen weight and spleen weight:body weight with the Wilcoxon matched pair rank test, and spleen weight:liver weight with the sign test.

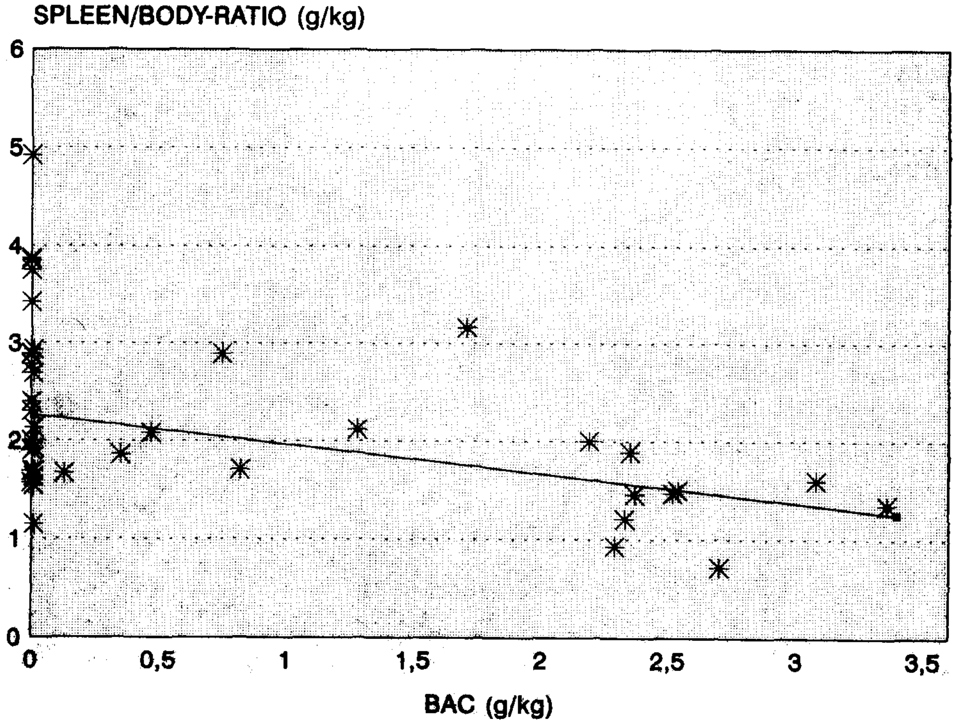

Fig. 3. Correlation between the ratio spleen weight:body weight and blood alcohol concentration in the drowning victims ($n = 42$).

4. Discussion

According to Stutte [9], the spleen weight post mortem represents ~0.2–0.3% of the body weight, so the authors' comparison group, comprising cases of asphyxiation due to causes other than drowning, would appear to be almost normal in this respect. There were only six instances (~14%) in which the spleen weight was under

Table 3
Spleen weights and spleen weight:body weight and spleen weight: liver weight ratios (range, mean (x) and standard deviation) in the 22 matched pairs without evidence of alcohol in the blood

	Drowning victims	Comparison group	P
Spleen weight (g)	75–320 $x = 158.2 \pm 64.3$	110–315 $x = 178.6 \pm 54.2$	~0.05
Spleen weight:body weight (%)	0.115–0.492 $x = 0.239 \pm 0.095$	0.153–0.407 $x = 0.269 \pm 0.067$	~0.05
Spleen weight: liver weight	0.05–0.17 $x = 0.09 \pm 0.03$	0.07–0.19 $x = 0.11 \pm 0.03$	~0.05

the lower limit. Therefore, although it cannot be established with absolute certainty on the basis of this study, it seems that a small spleen is not a consistent finding in asphyxiation and appears in fact to be a relative rarity here.

However, the spleen weights in the present authors' study group (drowning victims) were not only significantly lower than those in the comparison group, but were also under the lower limit of normal in half of the cases. It therefore appears that drowning is associated with a small spleen. However, the difference in distribution of spleen weights in the two groups indicates that this is not a constant finding in drowning: the minimal and maximal values in the test and comparison groups exhibited little difference. The main difference was a shift of the peak of the curve to the left, suggesting a process that is not operative in all cases.

Alcohol in the blood at the time of death appears to be of considerable significance. When the cases in which no alcohol was detected were considered alone, the differences were much less marked, although they always reached the 5% significance level with one of the statistical tests and were only just under this with the other. Since this was true not only for the absolute spleen weights but also for both weight ratio parameters, the authors consider, in view of the relatively small number of cases, that there was also a real difference in the cases in which alcohol was not detected. There is no doubt about the differences in spleen weight observed in the cases in which alcohol was detected and no doubt that these differences also increased with the blood alcohol concentration. This is quite a surprising finding. Firstly, it might be expected from the usual distribution of blood associated with lethal alcohol intoxication that there would be congestion of the spleen that would tend to counteract any reduction in size, especially in the presence of higher blood alcohol concentrations. Secondly, death as a result of reflex cardiac arrest, which is associated with a normal spleen size, has been discussed in the case of immersion deaths in which the victim was under the influence of alcohol [6–8].

The gross findings recorded in the autopsy reports in both groups were generally normal. Relevant abnormalities (such as flaccidity of the capsule) and details of the blood content of the spleen were recorded in only a few cases. Although there appeared to be a tendency towards the finding of a small, dry spleen in the study group, the probability value for the difference was >0.05. The strong subjective influence of the doctor performing the autopsy must be taken into account when considering these results. On questioning, none of the doctors involved felt that he could confirm the association of a small spleen with drowning from his own experience, although one said that he was not absolutely certain about this. In view of this, even the minor differences in these descriptive findings can be considered relevant.

Histological evaluation of the blood content of the spleen revealed no significant differences. Although at first sight this appears to conflict with the histomorphometric findings of Gatti [3,4], who found differences in erythrocyte density of only 10–20%, which would be compatible with the differences in organ weight that the authors found, but probably would not be detected with the less precise method of evaluation used in this study. This finding therefore does not rule out an association of reduced spleen size with drowning.

Thus, the authors' various investigations have not produced a definite, unanimous

Table 4
Incidence in the study group of various findings associated with drowning

	Number of cases	Relative incidence (%)
Emphysema aquosum	42	100
Foam in the respiratory passages	30	71
Small, blood-depleted spleen (<0.2% body weight)	21	50
Paltauf's spots	17	40
Watery gastric contents	14	30

conclusion. However, when the results of the individual investigations are reviewed, it is the spleen weight that must be considered the most important parameter. This is virtually free of subjective influences, unlike the descriptions of the gross findings, and is sufficiently accurate and sensitive, in contrast to the blood content, for which a difference can be determined only by morphometric methods. Therefore, the authors' investigations confirm that the small, dry spleen is a finding that may be present in drowning, probably in general but at least when there is also alcohol intoxication. On the basis of the findings in the group studied, a lower limit for spleen weight set, for example, at 0.2% of the body weight, would have considerable diagnostic value (Table 4). This would increase with an increase in the proportion of cases where alcohol was involved.

The pathophysiological mechanisms underlying the reduction in size of the spleen in drowning have not been fully established. However, certain observations made in animal experiments can at least be used as a basis for the development of hypotheses: hypoxia and a reduction in blood pressure lead to intense sympathetic stimulation and adrenalin secretion [10–12]. The effect of the humoral component is primarily vasoconstriction, and of the neural component, contraction of the capsule and trabeculae [13–15]. Both together, but not the reduction in blood flow alone, lead to an emptying of the spleen [16]. The spleen in man is an organ that is more involved in metabolism, unlike in most animals, where it has an important storage function. It therefore has very few contractile elements in the capsule and trabeculae in man [9], and, depending on the number of these elements, which varies from individual to individual, may react only to very intense stimulation. Predominance of the neural over the humoral influences [17] could explain why adrenalin levels after death by asphyxiation were not found to be higher than after other acute causes of death with a prolonged agonal phase and without characteristic spleen findings [18–20].

Another factor, cooling of the skin, can also be postulated as influential in the reduction in size of the spleen in drowning compared to other causes of asphyxiation. According to Bühring and Spies [21], cold leads to an increase in vagal tone with sympathico-adrenal counter-regulation. The fact that the spleen, unlike the other abdominal organs, possesses no parasympathetic nerve supply [22] and may thus be more sensitive to autonomic imbalances, may be an important factor here. According to the theories postulated by Bartsch [6], it is possible that cooling leads to a disturbance of the reactivity of the hypothalamus in the form of a pathological intensification. Bartsch, like Giertsen [23], felt that the simultaneous influence of alcohol was of critical importance here. This could explain the relationship between the spleen findings and the blood alcohol level the authors noted. This theory is also compatible with the finding of Yoshimoto et al. [24] that the pattern of biogenic amines in brains of animals that had died by drowning were different from those in animals that had died of asphyxiation due to other causes.

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