



MUELLER-MATRIX TOMOGRAPHY AS A METHOD OF DETERMINATION OF THE DEGREE OF BLOOD LOSS IN CASES OF INCISED-STAB WOUNDS IN VICTIMS OF DOMESTIC VIOLENCE

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Summary: *the article considers the possibilities of using the Mueller-matrix tomography method to determine the degree of blood loss due to incised-stab wounds caused during domestic violence. Purpose of the research to develop criteria for assessing the degree of blood loss in cases of incised-stab injuries with massive blood loss caused during domestic violence. Materials and methods. Blood smears from victims of domestic violence with massive blood as a result of incised-stab injuries were examined. Among the victims were women (n=27) aged 18 to 56 years old, with various degrees of blood loss from (500±100) mm³ to (2500±100) mm³. The research was carried out using a laser polarimeter of a standard scheme. Statistical data processing was carried out using MS® Excel® 2010™ and Statistica® 7.0 applications. Results. The obtained results of the study demonstrate a high level of accuracy (Ac - 82-94%) in determining the degree of blood loss in stab wounds due to domestic violence in the range of blood loss ΔV = (0±2000) mm³. Conclusions. The method of Müller-matrix polarization microscopy of human blood samples has a potential use in forensic medical practice, in order to establish accurate criteria for the degree of blood loss and severity of bodily injuries and ensure justice, which will contribute to reducing the number of cases of domestic violence.*

Keywords: *domestic violence, forensic medicine, blood loss, polarimetry*

Introduction: Domestic violence is a serious problem that, after years of existence, continues to remain a shadow, but recently it is gaining more and more attention in the modern world [1-3].

Domestic violence is a broad term covering any form of violence that occurs within the domestic environment between family members or intimate partners [2]. It includes: physical violence in the form of blows, beatings, mutilations, strangulation or any other actions aimed at inflicting physical injuries; emotional violence: psychological pressure, manipulation, threats, use of contempt or psychological trauma; psychological violence: psychological trauma, isolation from the social environment, contempt and other methods of mental influence [4-6]. Each of these forms of domestic violence can have serious consequences for the victims and the family as a whole. It is important to tackle all forms of domestic violence and support victims for their safety and well-being [7].

The causes of family violence are diverse and complex, but stress, alcohol or drug intoxication, lack of adequate ways to resolve conflicts, and the presence of violent relationships in the family are among the most common [2, 4, 6].

According to data from the World Health Organization, every third woman in the world faces physical or sexual violence in a relationship with a partner during her lifetime. Domestic violence results in the death and disability of thousands of women worldwide each year [2]. In addition, it has serious economic and social consequences for the family and society as a whole. Many cases of domestic violence remain unreported or unaccepted in society, due to stigmatization, fear or lack of appropriate response from law enforcement agencies [7].

Although violence can take many forms, but one of the most dangerous is physical violence with a weapon, which can result in serious injury and even death. Most often, in cases of domestic violence with the use of weapons, cutting and stabbing objects are used, which leads to severe traumatization of

the victims with possible massive blood loss. The key issue in such cases for the forensic medical expert is to determine the degree of blood loss [8-9]. After all, the volume of blood loss can serve as an objective indicator of the degree of gravity of physical injuries inflicted on the victim. This is important for assessing the severity of the crime and taking appropriate measures regarding the responsibility of the guilty parties. Providing clear evidence of the extent of blood loss can assist law enforcement in establishing liability and punishing perpetrators of domestic violence. This helps ensure justice and prevent similar cases in the future [10-13].

Therefore, determining the degree of blood loss is not only a forensic medical necessity for determining the degree of gravity of physical injuries, but also an important element in the legal process to ensure justice and safety of society.

Purpose of the research: to develop criteria for assessing the degree of blood loss in cases of incised-stab injuries with massive blood loss caused during domestic violence.

Materials and methods: Blood smears from victims of domestic violence with massive blood because of incised-stab injuries were examined. Among the victims were women (n=27) aged 18 to 56 years old, with various degrees of blood loss from (500 ± 100) mm³ to (2500 ± 100) mm³. The research was carried out using a laser polarimeter of a standard scheme (fig. 1). Statistical data processing was carried out using MS[®] Excel[®] 2010™ and Statistica[®] 7.0 applications.

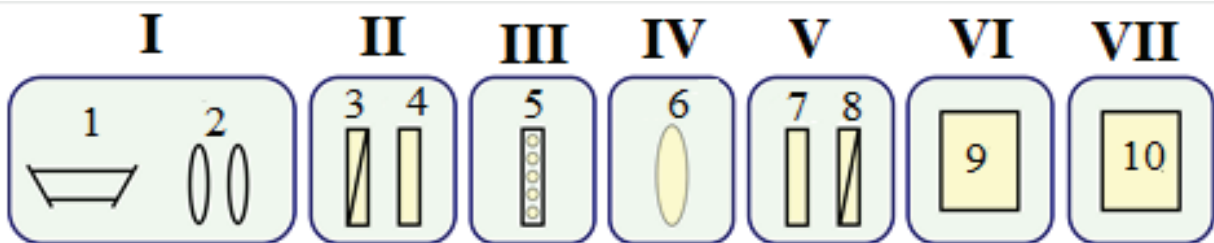


Fig. 1. Functional block diagram of multiparameter differential Mueller-matrix tomography of biological samples:

- I – lighting unit (1 – laser; 2 – collimator);
- II – polarization filter (3 – polarizer; 4 – quarter-wave phase plate);
- III – object unit (5 – biological sample);
- IV – projection unit (6 – polarizing microlens);
- V – polarization analysis unit (7 – polarizer; 8 – quarter-wave phase plate);
- VI – photoelectronic registration unit (9 – digital camera);
- VII – data processing unit (10 – personal computer).

Results: The proposed technique is based on the facts that in cases of blood loss there is a decrease in the concentration of formed elements of blood, which in turn is accompanied by corresponding changes in the structure of the coordinate distributions of circular birefringence (CB) of polycrystalline images of the structural elements of its components. For all selected samples, values of circular dichroism of polycrystalline blood films of victims with different degrees of blood loss were determined by Mueller matrix tomography.

The results of the statistical analysis of the specified changes in CB maps of polycrystalline blood films of all samples illustrate the statistical moments of the 1st - 4th orders, which are shown in Table 1.

Table 1. Statistical structure of CB maps of polycrystalline blood films of victims with different degrees of blood loss

Blood loss, mm ³	0	(500 ± 100) mm ³	(1000 ± 100) mm ³
Average (SM_1)	0.193 ± 0.0087	0.162 ± 0.0063	0.131 ± 0.0054
Dispersion (SM_2)	0.181 ± 0.0074	0.16 ± 0.0061	0.14 ± 0.0057
Asymmetry (SM_3)	0.55 ± 0.026	0.79 ± 0.035	1.07 ± 0.047
Excess (SM_4)	0.71 ± 0.034	1.12 ± 0.054	1.55 ± 0.069
p	<0,05	<0,05	<0,05
Blood loss, mm ³	(1500 ± 100) mm ³	(2000 ± 100) mm ³	(2500 ± 100) mm ³

Average (SM_1)	0.102 ± 0.006	0.078 ± 0.004	0.045 ± 0.002
Dispersion (SM_2)	0.12 ± 0.0054	0.103 ± 0.0045	0.082 ± 0.0036
Asymmetry (SM_3)	1.37 ± 0.059	1.68 ± 0.072	1.93 ± 0.095
Excess (SM_4)	1.96 ± 0.098	2.38 ± 0.11	2.72 ± 0.13
p	>0,05	>0,05	>0,05

It was established that the range of changes in the mean (SM_1), dispersion (SM_2), asymmetry (SM_3) and excess (SM_4) according to the level of blood loss is $(0 \pm 2500) \text{ mm}^3$. The linear change of these indicators can be seen in Figure 2

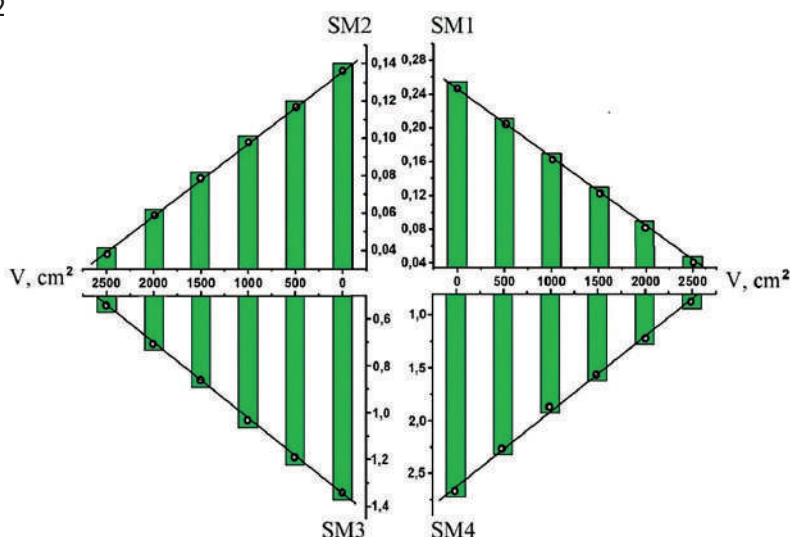


Fig. 2. Dependencies of mean (SM_1), dispersion (SM_2), asymmetry (SM_3) and excess (SM_4), which characterize maps of the CB of polycrystalline blood films of samples with different degrees of blood loss.

For each statistical moment, which characterizes the distributions of the value of the set of CB of blood samples for all victims of domestic violence, the accuracy of determining the volume of blood loss was found (table 2).

Table 2. Accuracy Ac, % of determining the volume of blood loss

Blood loss, mm^3	$(500 \pm 100) \text{ mm}^3$	$(1000 \pm 100) \text{ mm}^3$	$(1500 \pm 100) \text{ mm}^3$	$(2000 \pm 100) \text{ mm}^3$	$(2500 \pm 100) \text{ mm}^3$
Average (SM_1)	84	84	84	82	82
Dispersion (SM_2)	92	94	92	90	90
Asymmetry (SM_3)	94	94	92	92	90
Excess (SM_4)	92	92	90	90	88

The analysis of the obtained data revealed that for all the investigated blood samples, the range of sensitivity of the method of differential Mueller-matrix tomography of the circular dichroism of the polycrystalline component to the change in the volume of blood loss for all victims of domestic violence is the maximum level $(0 \pm 2500) \text{ mm}^3$. The accuracy of the method of differential Mueller-matrix tomography of circular dichroism of the polycrystalline component of blood samples varies within: $\Delta V = (0 \pm 2000) \text{ mm}^3 \leftrightarrow 82-94 \%$.

The maximum level is achieved for the following statistical parameters that characterize the circular dichroism maps of blood samples: $SM_2 \leftrightarrow 90-92 \%$; $SM_3 \leftrightarrow 90-94 \%$; $SM_4 \leftrightarrow 88-92 \%$.

Discussion: Incised-stab wounds with massive blood loss can not only cause physical damage, but also leave a psychological and emotional scar for life. In addition, domestic violence has a large impact on society as a whole, increasing costs for health care, law enforcement and social services [3-5].

In order to prevent domestic violence and especially its fatal consequences, it is necessary to pay attention to education and raising awareness in society. Effective prevention programs, legislative measures, and victim support are key components to successfully combating this problem [7].

The results obtained in this work using the Mueller-matrix tomography method to determine the degree of blood loss from incised-stab wounds can have a significant impact on decisions related to domestic

violence, especially in situations where sharp-edged weapons are used [10-12]. Our method allows you to accurately determine the degree of blood loss, which is critically important for a forensic medical expert when investigating cases involving victims of domestic violence. With accurate data on the degree of blood loss, the treatment and procedures needed to stabilize the victim can be effectively prescribed [12].

The results of our research can serve as objective evidence in court proceedings. The exact amount of blood lost, studied with Mueller matrix tomography, can be used to determine the severity of the crime and the responsibility of the guilty people. The obtained results can be used to create preventive programs and legislative measures aimed at preventing violence in the family. Understanding the tools and methods for determining the degree of blood loss can assist in developing effective strategies to protect victims and prevent future incidents.

Therefore, the use of the Mueller-matrix tomography method to determine the degree of blood loss from incised-stab wounds can play an important role in ensuring justice and preventing domestic violence.

Conclusions: The method of differential Mueller-matrix tomography of blood samples provides accurate determination of the volume of blood loss in the range $\Delta V = (0 \pm 2000) \text{ mm}^3$.

It is worth emphasizing the importance of research and the use of new methods, such as Muller-matrix tomography, to determine the degree of blood loss in case of incised-stab wounds as a result of domestic violence. On the basis of the obtained results, it is possible to develop more effective strategies for forensic examination and combating violence.

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