EVALUATION OF EFFICIENCY AND QUALITY OF MECHANICAL CLEANING OF AUTOPSY TOOLS IN ULTRASONIC CLEANERS

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Discharging their duties, doctors manning autopsy departments and forensic examiners contact infected biological objects and risk contracting infectious diseases. The risk they run is much higher than dangers faced by specialists involved in other aspects of forensic investigations. This study aimed to assess the effectiveness and quality of mechanized cleaning of autopsy tools in ultrasonic cleaners following standard operating procedures. We compared the results of sanitary and bacteriological examination of the said tools washed manually and mechanically, with the help of ultrasonic cleaners. McNemar's test used in the context of processing of the data allowed revealing the frequency of change of the monitored indicators between the two groups. Mechanical cleaning minimizes direct contact with the tools, allows decontamination of items of complex geometry (including their hard-to-reach parts) without damaging them and ensures high quality of cleaning. With ultrasonic cleaners, mechanized cleaning significantly shortens the time needed to clean medical tools, eliminates the need to wash them manually without compromising their operability, and brings down the risk of workplace injuries and occupational morbidity.

Keywords: forensic medical examination, ultrasonic washing, disinfection of autopsy tools, standard operating procedure

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ОЦЕНКА ЭФФЕКТИВНОСТИ И КАЧЕСТВА ОЧИСТКИ СЕКЦИОННОГО ИНСТРУМЕНТАРИЯ МЕХАНИЗИРОВАННЫМ СПОСОБОМ С ПОМОЩЬЮ УЛЬТРАЗВУКОВЫХ МОЕК

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Врачи — судебно-медицинские эксперты, работающие в секционных отделениях, при выполнении судебно-медицинских экспертиз трупов напрямую контактируют с инфицированными биологическими объектами, рискуют заразиться инфекционными заболеваниями, причем риск этот многократно выше, чем у других сотрудников бюро судмедэкпертизы. Целью исследования было оценить эффективность и качество очистки секционного инструментария механизированным способом с помощью ультразвуковых моек путем применения стандартных операционных процедур. Проведен сравнительный анализ качества обработки инструментов ручным методом и механизированным способом с применением ультразвуковых моек по результатам санитарно-бактериологических исследований. Полученные данные были обработаны методами математической статистики с использованием теста Макнемара (оценка изменения частоты признака в двух группах). Очистка инструментов механизированным способом сводит к минимуму тактильный контакт медицинского персонала, позволяет обработать изделия сложной конфигурации в труднодоступных местах, не повредив их, обеспечивая высокое качество очистки. Механизированная очистка инструментов с применением ультразвуковой мойки позволяет значительно сократить время обработки изделий медицинского назначения, исключить ручную отмывку медицинских инструментов, сохранить рабочие свойства дорогостоящих медицинских инструментов и изделий, свести к минимуму риск производственного травматизма и профессиональной заболеваемости.

Ключевые слова: судебно-медицинская экспертиза, ультразвуковая мойка, дезинфекция секционных инструментов, стандартная операционная процедура

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According to statistics, 89% of all occupational diseases contracted by medical professionals are the result of exposure to biological factors [1]. Discharging their professional duties (autopsies, material evidence examination etc.), forensic experts run a high risk of infection, especially with bacterial and viral agents. It should be remembered that forensic investigations department (FID) of the Forensic Bureau performs autopsies of bodies of people that led antisocial life and had various infectious diseases, including socially significant or highly dangerous ones, which, in many cases, remained undiagnosed because such people did not request medical assistance when they were alive [2–4].

The professional environment of a thanatologist is swarming with pathogenic microorganisms; its bacterial contamination potential is high and the associated processes intense. Clearly, such working conditions force the body to decrease the immune status and reactivity, which ups the risk of contracting various infections, including the highly dangerous ones [5].

To minimize the risk of infection for its medical staff, the bureau adopted special operating procedures (SOP) designed to improve biological safety of the employees [6].

One of the promising measures aimed at protecting specialists working at FID implies using ultrasonic washers in the process of mechanized cleaning of tools used for autopsies. This measure allows skipping the most injury-prone and labor-intensive stage: manual cleaning with the help of brushes and other mechanical aids that are often sharp and unhandy. Ultrasonic washers require medical staff to only load the trays and take the clean inventory ready for work once the cleaning cycle is complete. These devices allow decontaminating the tools up to 4.5 times faster [7, 8]. Moreover, ultrasonic cleaning eliminates the need to use organic solvents, and the waves can reach even the parts most hard to access. No joints, crevices, openings, orifices or cavities can compromise effectiveness of an ultrasonic washer; the process is totally safe and, at the same time, delicate.

Thus, the key advantages of mechanized cleaning of tools are obvious: minimization of direct contact with the cleaned tools; possibility to clean many tools within a short period of time; increase of the service life of expensive tools through curtailing the damage thereto associated with cleaning; high quality of cleaning of the hard-to-reach parts of tools of complex geometry [9, 10].

Ultrasonic washers are especially effective for mechanized disinfection and pre-sterilization cleaning of smaller piercing and cutting medical tools of complex geometries. By its nature, the contamination can be water-soluble and partially soluble, polar organic and non-organic compounds, blood, protein etc.; solid and liquid films of oil and fat of phytogenic, mineral (new tools) and animal origin, etc. [11].

For FID, ultrasonic washers are an optimal solution in the context of forensic investigation activities.

The purpose of this study was to evaluate the effectiveness and quality of mechanized cleaning of autopsy tools with ultrasonic washers based on the results of sanitary and bacteriological test.

MATERIALS AND METHODS

To evaluate the quality of cleaning of autopsy tools (trays, knives, scissors), we conducted a number of sanitary and bacteriological tests at FID of the Republican Forensic Bureau of Healthcare Ministry of the Republic of Tatarstan, within the period from February, 3 through June, 18, 2021.

We compared the results of manual and mechanized cleaning of the said tools, the latter involving ultrasonic washers. Through the time period stated above, we collected 72 samples (swabs) and tested each for S. aureus coliform bacteria. All the samples were taken from the surface of the tools used for autopsy and washed mechanically afterwards. Collecting the samples, we followed guidelines given in MUC 4.2.2942-11 "Methods of Sanitary and Bacteriological Testing of the Environmental Objects and Air in Medical Facilities and Control of Sterility therein" [11]. We have not detected S. aureus neither in the experimental nor in the control group, therefore, all calculations and assessment of effectiveness were based on the data on contamination with coliform bacteria exclusively.

We formed two groups, experimental and control. The latter group included 36 samples swabbed from the tools cleaned by a forensic expert's aide at the end of the shift or an autopsy; the aides cleaned tools only of the experts they were working with through the shift. In other words, the pattern was "individual and decentralized manual cleaning of the tools." The samples were swabbed after washing and drying.

The experimental group included 36 samples swabbed from the tools that were cleaned after an autopsy or at the end of the shift as follows: primary disinfection, then rinsing with water, then, as per the respective SOP, disinfection and pre-sterilization treatment in an ultrasonic washer (lockable tools were put into the disinfecting solution open). Cleaning of all the tools was a centralized process that followed a single routine described in the SOP. There were no individual sets of tools. The samples were swabbed after washing and drying.

We used the mathematical statistics methods to process the resulting data; the software used for the purpose was Microsoft Excel 2010 (Microsoft; USA). McNemar's test was applied to assess the results of microbiological tests and find out the frequency of change of the monitored indicators between the two groups. The difference was considered significant at $p = 0.001$.

RESULTS

Sanitary and bacteriological testing of swabs from surfaces of tools aimed at detecting coliform bacteria revealed that such were significantly more often found in samples taken before application of SOP than after these procedures were carried out (Table 1).

Table 1. Presence (1) or absence (0) of coliform bacteria in swabs from surfaces of metal tools used in the FID of the Forensic Bureau of Healthcare Ministry of the Republic of Tatarstan.

Samples taken from	Before application of SOP				After application of SOP			
	Sampling dates in 2021							
	03.02	08.02	10.02	17.02	02.03	09.03	30.03	19.04
Tray	0	0	0	0	0	0	0	0
Knife	0	0	0	0	0	0	0	0
Scissors	1	0	1	0	0	0	0	0
Tray	0	0	0	0	0	0	0	0
Knife	0	0	0	0	0	0	0	0
Scissors	1	0	1	0	0	0	0	0
Tray	0	0	0	0	0	0	0	0
Knife	0	0	0	0	0	0	0	0
Scissors	0	1	0	0	0	0	0	0

Table 2. The 2 × 2 four-field table based on the results of tests of surface swabs (source - autopsy tools) for coliform bacteria

	A2 = 1	A2 = 0	TOTAL
A1 = 1	6	0	6
A1 = 0	30	36	66
TOTAL	36	36	72

Note: A1 — monitored indicator before the experiment; A2 — monitored indicator after the experiment.

Table 2 (2 × 2, four fields) shows the results of surface swabs tests for coliform bacteria, which allowed calculating the chi-squared value (χ^2) using the McNemar's test, the result of this calculation being 30. The drop in frequency of occurrence of the monitored indicator is significant, $p < 0.001$.

Thus, we can affirm that adoption of SOPs prescribing the order of treatment and disinfection of autopsy tools translated into a significantly less frequent detection of coliform bacteria.

DISCUSSION

As noted by a number of authors [6, 12, 13], introduction of standards in medical institutions increases their overall effectiveness and improves safety of the staff.

Assessment of results of sanitary and bacteriological tests has shown that the algorithm for processing autopsy tools, as adopted at the FID of Republican Forensic Bureau of Healthcare Ministry of the Republic of Tatarstan and established in the respective SOP, is the most effective one. It ensures the highest quality of cleaning and treatment of the tools. The algorithm includes washing the tools with cold and hot water, manual mechanical removal of large organic contaminants and primary disinfection by the sectional table, then rinsing with running water, mechanized disinfection and pre-sterilization in an ultrasonic cleaner and, finally, the final washing and drying of tools. The advantages of mechanized disinfection and pre-sterilization of tools have been conformed in several works [5, 14, 15].

The tests for coliform bacteria returned positive only for swabs taken from tools with a complex geometry (scissors), which suggests that the quality of manual washing and disinfection of tools is largely dependent on the human factor, when each forensic expert or his/her aide cleans their own tools and bears full responsibility therefor. Regulatory documents of the Forensic Bureau prescribe no rules for treatment of tools nor responsibility for their violation. Washing the tools in an ultrasonic cleaner offsets this factor completely.

Based on the results of sanitary and bacteriological tests showing significant effectiveness of the experimental routine, the Republican Forensic Bureau of the Healthcare Ministry of Republic of Tatarstan has made a number of managerial decisions:

1) ultrasonic cleaners were purchased for the Bureau to be used for disinfection and pre-sterilization of the autopsy tools;

2) forensic experts were prohibited from using "personal" autopsy sets they could process individually, cleaning and disinfection became centralized;

3) Bureau's regulations were extended with the requirement to mandatorily and in a centralized manner clean and disinfect all tools used in autopsy and biomaterial sampling after each session, regardless of the cause of death;

4) forensic experts received instructions on standard operating procedures prescribing the order of mechanized disinfection and pre-sterilization of autopsy tools in ultrasonic cleaners, as well as the SOP outlining the process of assessment of the quality of cleaning in such devices.

CONCLUSIONS

Thus, adoption of the mechanized cleaning routines (including those involving ultrasonic cleaners) by medical institutions significantly shortens the time needed to clean medical tools, protects medical staff from dangerous infections, eliminates the need for manual washing, extends service life of the expensive tools significantly, and brings to naught the risk of workplace injuries and occupational morbidity. The use of new technology should be regulated by clear instructions, recommendations and SOPs for personnel, with control over their activities and quality of cleaning enabled by the equipment.

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