Revisión / Review

Biosafety in autopsy room: an systematic review

Bioseguridad en la sala de autopsia: una revisión sistemática

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ABSTRACT

Objective To discuss the risks related to the possibilities of accidents and contamination in autopsy rooms, especially the biological risk.
Methods This is an exploratory study. The databases Lilacs, MEDLINE and SciELO virtual library were searched; from 2000 until 2017; from the following inclusion criteria: articles available in full, in Portuguese, English and Spanish languages; and those that portrayed the central theme of the article.
Results 53 articles were analyzed, to following the sub-themes: chemical, ergonomic, biological and accident agents; exposure to radioactive materials; electrical and electronic equipment.
Conclusions The death cause is essential for epidemiological surveillance. The prevalence of diseases in the population poses risk to autopsy room professionals. Often these diseases are not detected before death; can coexist with other conditions and be ignored; or don't have morphological evidence at autopsy. *M.tuberculosis*, hepatitis virus, HIV and prions were the main pathogens identified. They can be transmitted by blood and aerosols; but there are other risks such as sharps, chemicals and radioactive materials.

Key Words: Autopsy; containment of bioharzads; biosafety (*source: MeSH, NLM*).

RESUMEN

Objetivo Discutir los riesgos relacionados con las posibilidades de accidentes y contaminación en las salas de autopsias, especialmente el riesgo biológico.
Método Este es un estudio exploratorio. Se realizaron búsquedas en las bases de datos Lilacs, MEDLINE y la biblioteca virtual SciELO, desde 2000 hasta 2017, de los siguientes criterios de inclusión: artículos disponibles en su totalidad en portugués, inglés y español, y aquellos que retrataron el tema central del artículo.
Resultados Se analizaron 53 artículos, siguiendo los subtemas agentes químicos, ergonómicos, biológicos y de accidentes; exposición a materiales radiactivos; equipos eléctricos y electrónicos.
Conclusiones La causa de muerte es esencial para la vigilancia epidemiológica. La prevalencia de enfermedades en la población representa un riesgo para los profesionales de la sala de autopsias. A menudo, estas enfermedades no se detectan antes de la muerte; pueden coexistir con otras condiciones y ser ignoradas, o no se tiene evidencia morfológica en la autopsia. *M. tuberculosis*, virus de la hepatitis, VIH y priones fueron los principales patógenos identificados. Se pueden transmitir por sangre y aerosoles; pero existen otros riesgos como objetos punzantes, productos químicos y materiales radiactivos.

Palabras Clave: Autopsia; contención de riesgos biológicos; bioseguridad (*fuente. DeCs, BIREME*).

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Hospitals are complex workplaces, where biological agents circulate, which represent risk, latent or manifest, or even unknown. The handling of shar-ps, electrical materials and floors with smooth surfaces, are characteristics of the vulnerability of safety conditions.

Although a needle accident may result in infection, with a latency period of 90 to 180 days; exposure to radiation; contact with drug mists or biological aerosols produced by investigative activities may show symptoms years later.

Even after the efforts of infection control measures, some risks remain neglected, such as disrespect for parameters related to filtration, flow and air renewal.

Improvements have been observed, but autopsy are still "forgotten". These workplaces have functional criteria and specific demands.

Despite the number of autopsies has decreased, its value is undeniable in determining the cause of death, detecting clinically unknown lesions, collecting samples for analysis, confirmation or correction a diagnosis. Often it is the only way of conclude it (1-4).

Autopsy rooms are considered as one of highest risk areas of the hospitals (2-6). A priori the death-causing agent is unknown, so there is a potential occupational exposure risk (6,7). Unexpected situations or accidents are frequent, due to the great heterogeneity of manipulated materials. Scalpels, needles, bones fragments and teeth can result in percutaneous injuries. Organ manipulation increases exposure to body fluids and blood, use of instruments, hoses and saws produce aerosols contaminating items or allowing inhalation (7,8).

This study discusses the risks that can cause accident and/or contamination in autopsies, especially biological ones.

METHODS

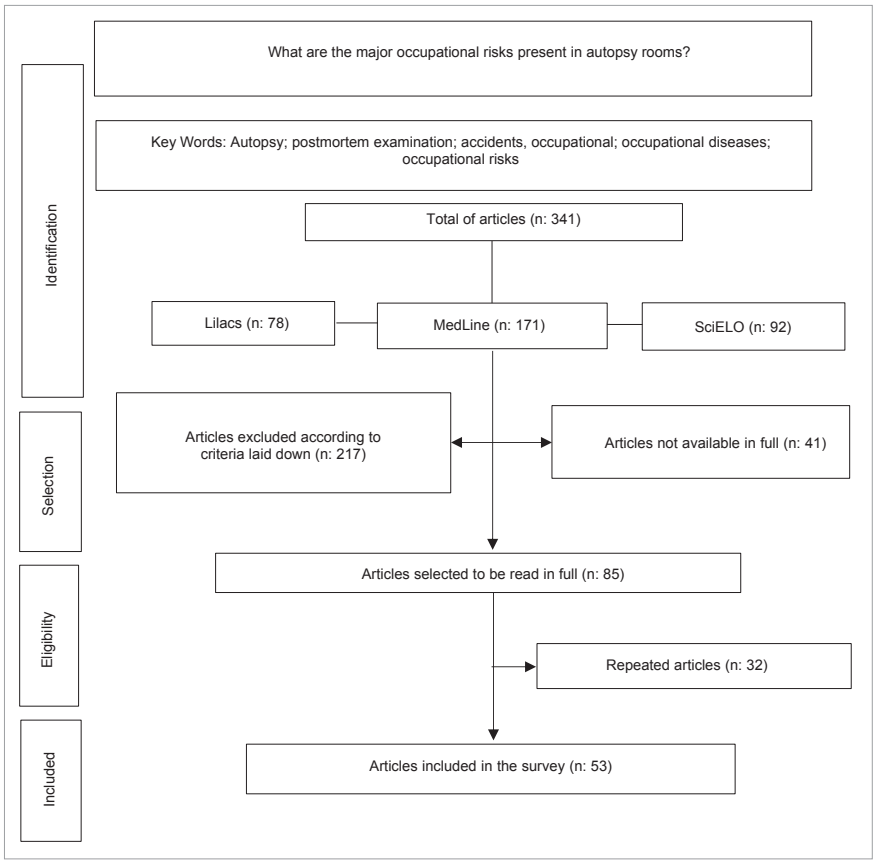
Exploratory study focusing on systematic review as facilitator to build analyses of risk situations. This method summarizes researches results, aiming to understand a particular fact, based on previous studies, producing innovative conclusions (9). The procedures include a descriptive qualitative approach.

The guiding question was: what are the main occupational risks in autopsy rooms?

The search was conducted in databases: LILACS and MedLine, and in Scientific Electronic Library Online (SciELO) virtual library.

The Mesh terms and the boolean operators OR and AND were used, resulting in the combination: ("autopsy" OR

Figure 1. Search and selection strategy



"postmortem examination") AND ("accidents occupational" OR "occupational diseases" OR "occupational risks").

The search were developed in Jully 2018, and covered the period 2000-2017. Initially, the screening was done by titles and abstracts. All duplicates were removed. The studies were selected on the basis of the following criteria: a) language: Portuguese, English or Spanish; b) theme related to Biosafety in autopsy; and c) full text available. Abstracts, editorials, letters, articles with general content and without the specificity of autopsy were excluded. Then, the contexts were analyzed and integrated into sub-themes, according to the conceptual perspective of each context.

RESULTS

341 articles were found, which were analyzed for eligibility criteria for inclusion in the study. Duplicates and articles not available in full were removed, leaving 53 articles (Figure 1).

After reading, the articles were grouped by similarity and relevancy, into subtopics, to be discussed.

Occupational risks

Flavin (10) demonstrated that autopsy workers have a risk 10 times higher when compared to the population, and a 100-200 times greater chance of facing individuals without diagnosis, when compared to other healthcare professionals.

Most bodies sent to autopsy have no history or insufficient medical information. In addition, 20% to 30% of patients died in hospitals have important diseases or lesions not detected before death, but only during autopsy (3,4,11). Identification of the causes of morbidity and mortality, knowledge of the natural history of diseases, including previous outbreaks; can help to determine the

Table 1. Occupational hazards for autopsy room workers

Activity	Problem	Reference
Ergonomic risk agentes a. Use of heavy equipments/loads. b. Transportation of bodies on slippery floors. c. Stance – the work is routinely performed standing up. d. Extreme focus and attention. e. Repeatability. f. Stress. g. Human suffering.	Accidental injuries. Musculoskeletal injury-particulary back strain. Repetitive Strain Injury. Depression. Absenteeism. Slipping and falling-bruises, fractures.	(6,7,13-22)
Handling of dissection tools a. Scalpel, scissors, saws, needles. b. Fragmented firearm projectiles. c. Punctuated ends of fragmented bones. d. Medical devices. e. Needle fragments in drug addicts.	Cutting or puncturing – the parts most frequently affected are distal phalanges of the thumbs, middle finger and index finger.	(6-8,10,12, 14,15,17,20, 22-33)
Eletricity a. Instruments (power saws). b. Eletrical installations and connections. c. Defibrillators/pacemakers (often found in corpses).	Shock and electrocution. Power tools (saws) are routinely handled with wet gloves.	(6,7,12-15, 21,25,34)
Exposure to biological material a. Splashes/contact. b. Wounds. c. Mucous surface. With blood, body fluids and cadaver tissues with infectious diseases, drug addicts, etc.	Aerosols Blood/body fluids: transmitting agents such as: HIV, hepatitis B, hepatitis C, tuberculosis, parasitic infections, *Staphylococcus*, *Streptococcus*, *Salmonella* and others.	(3, 5-8,10-12, 14, 18,20, 23-25,27,28,32, 33,35-52)
Exposure to radioisotopes a. Radioactive materials inoculated for cancer treatment. b. Exposure to X-rays before/during an autopsy when X-rays are taken routinely.	Possible risk of radiation injuries malformation and congenital anomaly in pregnant workers.	(7,8,14-16,21,22, 53-56)
Handling of chemicals a. Formaldeyde - used for the preservation and fixation of tissues for histopathological examinations, to maintain cellular and tissue structures in good condition, thus preventing or delaying the process of degradation caused by autolytic phenomena. There is also the handling of organs or other biological material fixed in formalin. b. Lack of ventilation and/or exhaustion failures. c. Exposure to aerosols from volatile or highly poisonous chemicals (e.g. Malathion, Parathion) - deaths from cyanide poisoning at the time of opening the stomach or other body cavities.	Formaldehyde causes irritating effects to the eyes and mucous membranes, the respiratory tract and the skin, and also alters the menstrual cycle and produces reproductive disorders. Carcinogenic. Genotoxic. It causes an increase in the concentration of risk agents in the air and may produce irritability or help contamination. Toxic gas poisoning (acute/chronic effects). However, chronic toxicity is the most common event.	(6-8,12, 14-18,20,22,25, 35-39,57-61)

risk represented by corpses (4,11). However, the occupation of the dead patient should also be considered. Drug addicts or prostitutes become more susceptible to violent or inexplicable deaths. But all patients should be considered suspected to contain pathogens, regardless of having a history of infection or belonging to a risk group (6,12).

There are other risks during the autopsy. Table 1 shows the consequences of the risks identified.

Chemical agents

Formaldehyde, employed in the preservation of tissues, is the chemical most used in the autopsies. Despite high concentrations being required for the preparation of bodies, the concentration of formaldehyde in air depends on the contents of the fluid, kind of body, ventilation and work process. OMS studies (60) indicate concentrations above 1,2mg/m^3 around the autopsy tables.

Formaldehyde is highly volatile and causes several symptoms, including ocular, mucosal and skin irritation (17,57,59). Long-term inhalation has been associated to an increased risk of developing cancer, especially lung cancer (14-17,57,59). OSHA limited occupational exposure to 0,75 ppm/8 hours and 2,0 ppm/15-minute periods (61).

Deaths from intoxication by organophosphates, like malathion, parathion, or cyanide, cause toxicity through inhalation, ingestion or dermal absorption. The greater risk is when the stomach is opened, as cyanide reacts with stomach acids and is converted into hydrogen cyanide, a highly volatile gas (12,15,18,22,35,60). Thus, they should be opened in biological safety cabinets. Personal items and contaminated clothing should be handled with gloves (7,36).

Neurotoxic gases used in acts of terrorism, like tabun, sarin, VX and soman; can penetrate slowly through gloves and rubber aprons and be absorbed by the skin. The bodies must be washed with water or alkaline solutions (25,37,38). The professionals must wear positive pressure protective suit, butyl or neoprene gloves; air purifying respirators with cartridges for organic vapors, since corpses can produce vapors. At ambient levels of 10 grams of agent/m^2 area, respirators can be used for until 24 hours (38).

Radioactive materials

Diagnosis or therapeutic procedures using radioisotopes before death can pose a risk to autopsy workers (8,16,21,54). Generally, diagnostic products have short half-lives and more penetrating emissions (gamma rays), while therapeutic and implant radioisotopes have longer half-lives and constitute risk for long time (53).

Thus, risk assessment should be performed to understand the extension of exposure from the dose administered to the patient, type of emission, radioisotope used and time of exposure (7). These will determine the procedures and protection equipment, as well as the safe release of the body for the funeral home. Bodies containing long half-life isotopes like Strontium-90 should not be submitted to autopsy and placed in sealed coffins (55). It is necessary to monitorize exposure and radiation levels. The instruments and the environment need to be decontaminated (8,14,15).

Electrical equipment and electronic devices

Electric equipment, like automatic saws, associated to the presence of water, increase the risk of shocks. Thus, preventive maintenance of equipment, insulation and grounding systems are important measures (7,14,15,25).

Another risk is implantable cardiac defibrillators used for tachyarrhythmias. The professionals may be hit by an electric discharge (25 to 40 Joules). This devise cannot be found before the autopsy, when found, the autopsy must be suspended until it is deactivated (12,34).

Ergonomic risk agents

Ergonomic risk agents are directly related to the routine (13-16). The use of heavy equipments and the movement of corpses (21,22) affect principally the assistants by physical effort. To avoid this, mechanical means should be used, like cranes or "transfer systems", which work as a conveyor belt between the stretcher and the autopsy table (21).

Non-height adjustable tables demands inadequate postures or use of platforms. When it is not possible to adjust the height, use lifting elements, with supports and non-slip surfaces, avoiding improvisations with boxes (17,20,21).

Seated position, repetitive and monotonous movements contribute to spinal problems, muscle pain, tendinitis and bursitis (13,17,18).

Factors like responsibility, focus, pressure and suffering of family members, view of burned or mutilated bodies, sounds, structural deficiencies, as frequent inadequacy of exhaust systems, which cause the presence of smells; cause tension, suffering, irritation, insomnia, increase of mental pathologies like fatigue, chronic stress and Burnout Syndrome (19).

Accident risk agents

Autopsy rooms have several accident risk agents. Emphasis given to inadequate physical arrangement, humidity and presence of power cables on the floor. It's recommended to use waterproof electrical outlets, suspended above the work area (21). A drainage system for waste water and fluids produced and the use of non-slip flooring will reduce falls, humidity and prevent the proliferation of microorganisms.

The use of sharps, scalpels, scissors, forceps, knives and saws can cause percutaneous injuries, exposing workers to infections (12,14,15,22,24-26). Babb (30) recorded accidental puncturing of hands during autopsies, 38% among assistants and 12% among forensic pathologists. About 67% were inflicted on the distal fingers, the index fingers and the middle fingers of the non-dominant hand.

The corpse may contain perforating objects from a previous medical intervention not documented, like filters in the vena cava (31). There are reports of HIV contamination after accidents with fragments of needles in autopsies of subcutaneous intravenous drug user (17,27). There are other infections that can be transmitted by direct inoculation, like tuberculosis, blastomycosis, hepatitis B and C, rabies, tularemia and some types of viral hemorrhagic fever (6,7,23,25). Radiologic examination helps to locate these fragments.

Biological agents

Discrepant diagnoses are common and a substantial number of infections are detected only after postmortem analysis, even the most common such as pneumonia, sepsis, meningitis, peritonitis and endocarditis (3,5). 80% of coexisting infections are ignored; and even when diagnosed during life, the autopsy reveals that disseminated infections, such as bacterial endocarditis and acute pyelonephritis are underdiagnosed (62).

The presence of asymptomatic diseases without morphological evidence during autopsy poses a risk (50) and shows the importance of investigation the cause of death. The diagnosis will provide information, facilltate the contact management, infection patterns, control of outbreaks and identification of new infections and threats (3,11).

Autopsy professionals are exposed to pathogens transmitted by direct or indirect contact, by aerosols or by injuries and accidents caused by sharps (7,8,10,23,28,29,32). This risk is exacerbated by high seroprevalence of certain pathogens.

Exposure to aerosols is important in the autopsy room. Aerosols are particles smaller than 5 µm, remaining suspended in the air for long periods of time, or carried away by air and inhaled. These particles pass through the respiratory tract, reaching the pulmonary alveoli (8,12,33). However, particles with diameters greater than 5 µm (droplets) also pose a risk. They are heavier and reach smaller distances, being restricted to the autopsy table.

Aerosols are generated by fluid aspirators and hoses that spray water over tissues. The saws applied to the bones produce large amounts of dust and aerosols, distributed throughout the room and remain in the air for up to 1 hour, within a radious of up to 15 m from the saw, despite the ventilation system (33). However, even compression and dissection of the lungs using autopsy tools can produce aerosols and droplets (12).

Nonetheless, infection is a complex multifactorial process, requiring the presence and exposure to pathogen, and a susceptible host. Susceptibility is related to aspects which determine the individual's resilience (63). Pathogens have parameters to be analyzed, including virulence, transmission mode, drug resistance, stability, endemicity, availability of treatment and effective prophylactic measures. Regarding the activity, the concentration, volume of the manipulated material and the possibility of aerosol formation need to be assessed (63). This analysis will determine the risks and protection and containment measures (23).

Biological agents are classified into 4 risk groups (RG), increasing in degree of protection and containment required. RG3 and 4 agents have respiratory transmissibility power, and therefore pose greater risk (9,23). Table

Table 2. Classification of biological agents in risk group

Risk group	Characteristics	Biological agents reported	Reference
2	Biological agents that can cause infections in human or animals, whose potential for propagation in the community and dissemination in the environment is limited. There is effective prophylaxis available. Effective therapeutic measures for acquired infections.	*Staphylococcus*. *Streptococcus*. *Salmonella*. Rubella virus. HBV, HCV.	(7,8,28,29,39,40,41,43, 45,46,49,50,64)
3	Biological agents with transmission capacity, especially by the respiratory route, and which cause potentially lethal diseases in humans or animals. They can spread from person to person and have the potential for spreading in the environment. There are prophylactic and therapeutic measures generally available.	Human immunodeficiency virus (HIV) *Mycobacterium tuberculosis*. Rabies virus, Japanese encephalitis, tuberculosis, Rift Valley Fever virus and Yellow Fever virus. Coronavirus related to severe acute respiratory syndrome (SARS-CoV). Creutzfeldt-Jakob disease.	(7,8,10,28,29,32,40-43,46-51,54,64)
4	Biological agents with great transmissibility power, especially by the respiratory route, or with unknown transmission method. High risk of spreading to the community and the environment. There is no effective prophylaxis or therapy against infections caused by them.	Smallpox virus. Viral hemorrhagic fever, Ebola virus, Marburg vírus, Lassa vírus, Russian spring summer encephalitis virus.	(7,8,12,39,41,43)

2 shows the RG of etiological agents of diseases most frequently reported.

RG1 agents do not cause disease in healthy adults and their absence is justified by the fact that the normal flora of a healthy person is composed of RG2 agents.

DISCUSSION

This study identified the following pathogens: *M.tuberculosis*, hepatitis virus, HIV and prions responsible for transmissible spongiform encephalopathies. All of them maintain infectivity after death (28,40-42,64), cause diseases often asymptomatic, with no morphological evidence at autopsy.

a) Mycobacterium tuberculosis

Tuberculosis is most prevalent among HIV-positive individuals, prison inmates, intravenous drug users, and ethnic groups in countries with high TB rates. The emergence of multidrug-resistant strains emphasizes the importance of risk assessment.

It is not uncommon cases of active tuberculosis be identified only after autopsy. The presence of nonspecific symptomatology, cost-effectiveness of diagnostic tests and early death, are the most frequent causes of undiagnosed tuberculosis (54).

A study in the USA, from 1985 to 1988, identified 5,1% of cases of tuberculosis during postmortem (48). This data may explain the higher incidence of tuberculosis among autopsy workers (10%) compared to pulmonologists (4%) and other medical specialties (1%) (10,41). 90% of cases of occupational tuberculosis occurred due to aerosolized *bacilli* (12).

Nolte (7) described an outbreak of multidrug-resistant tuberculosis, attributed to positive pressurization of an autopsy room, where exhausted air circulated through the facility. However, transmission of tuberculosis can also occur in facilities with adequate pressurization and exhaust systems, but lacking proper personal respiratory protection.

Sterling (45) showed the presence of viable *bacilli* 24 to 48 hours after the embalming of a body, demonstrating the potential for aerosol transmissibility during formalin-fixed tissue dissection.

Another occupational infection is tuberculosis verrucosa cutis, which accounts for 5-10% of cases of infections among autopsy workers (44). The *bacillus* can be introduced into the skin through previous lesions or punctures.

It is advisable to introduce 10% formalin into the lungs through the trachea, as well as immerse the organs in it for 24 hours, after evisceration and before dissection. All unfixed tissues need to be manipulated in a biological safety cabinet. Bodies not yet fixed must not be handling. Sputum, pus, tissue and urine samples must be manipulated as little as possible, to avoid splashing and aerosol formation. The instruments used must be sterilized, preferably by physical means (7). Other recommendations include restricting the movement of people in the room and the use of hand saws in place of power equipments (46). Biosafety measures should include engineering and administrative controls, ventilation recommendations (negative pressure and exhaustion by HEPA filters), respiratory protection with N95 masks and post-exposure chemoprophylaxis.

b) Human immunodeficiency virus

The risk of seroconversion of autopsy personnel after contact with HIV positive blood is low (0-0,42%) (12,14) and most documented cases occurred after injuries caused by sharps, especially needles (6,51). This percentage may be underestimated when compared to the risk associated with deep accidental scalpel injuries. Post-exposure seroconversion will depend on the patient's viral load, inoculated volume and worker's susceptibility (6,51). The viral load on CD4+ T cells in the peripheral blood is higher during the acute phase and in the late stages of the disease. Thus, autopsy titers may be higher than in living patients (12).

Studies have demonstrated the viability of the virus in blood, pleural and pericardial fluids of cadavers stored at 20ºC after 16½ days (6,39). It was isolated from cranial bone, spleen, brain, cerebrospinal fluid, blood, bone marrow and lymph nodes during autopsy in bodies stored at 6°C, after five days from postmortem (12,23). In 2006, HIV was detected in corpses six days after a tsunami in Indonesia (23).

Surfaces and materials should be decontaminated with 0,5% sodium hypochlorite, 1% glutaraldehyde, or 3% hydrogen peroxide. However, besides corrosive, sodium hypochlorite reacts with formaldehyde to produce dichloromethyl ether, a powerful carcinogen (12).

c) Hepatitis B and C

Viral hepatitis is the most frequently disease reported (6), but there is a lack of studies about the prevalence of occupational infectious.

Hepatitis is universally distributed. Its prevalence coefficients are directly related to the populations at risk (drug users, prostitutes, individuals with tattoos, transplant patients, etc.) (6,7,39,40,41,44).

Gharehdaghi (40) showed a 15,5% risk of HIV, HBV and HCV contamination in the handling of bodies (2,6%, 3,8% and 9%, respectively). These data are important because HBV is about 100 times more transmissible by blood and aerosols than HIV (6). HBV is highly infec-

tious and its transmission can occur after exposure to infected blood in extremely small amounts. However, the risk of occupational acquisition is low, due to the routine vaccination. Nonetheless, there is no immunoprophylaxis for HCV; although, the risk of transmission after percutaneous exposure (2,7-10%) is lower than that of hepatitis B (30%) (6,25,46).

Data show that 3% of reported cases of acute hepatitis C are associated with needle puncture (6,8). Among autopsy professionals who have suffered perforations, the chance of acquiring HBV infection is 5%; however, if the blood contains the HBsAg antigen, the risk may be higher (up to 30%)(29).

HBV persists on surfaces at room temperature for 7 days, allowing for indirect transmission (6).

Autopsy helps to clarify the cause of death, vital for epidemiological surveillance to detect emergencies, diagnose isolated cases or during disease outbreaks.

Public health is currently in crisis, reflecting on the quality of facilities and services. Therefore, it is important to implement biosafety principles to prevent, reduce, eliminate and control risks, which could compromise public health, the environment and thus improve quality. Therefore, it is necessary to break requires breaking paradigms, such as changes in habits and culture.

In planning autopsy areas, physical space should be an essential aspect as it contributes to ensuring safety. This areas needs to be subdivided according to minimum safety standards. The first of them, "clean areas", includes offices and reception spaces. The second is a "transition area" made up of passage zones, such as corridors; access locker rooms, where personal protection equipment is stored; sanitary facilities; storage areas for bodies and parking of body transportation vehicles. The last, "dirty area", composes of: *postmortem* room, waste storage; decontamination and cleaning areas. In addition, a risk assessment is important for determinate the Biosafety Levels (BSL). BSLs can be applied to autopsy, as they guide the safe management of biological agents. There are 4 levels, but since there are no RG1 agents in autopsies, the levels begin at BSL2. BSL2 provides protection for most blood-borne agents where universal precautions are required for routine operations. BSL3 provides protection against potentially airborne agents, which can cause serious or potentially lethal diseases. BSL4 provides protection against exotic agents, with unknown pathogenic potential, and cause fatal diseases, for which there are no vaccines or treatments.

In Brazil, 72% of the etiological agents of notifiable diseases are RG2, 19% are RG3 and 9% are unknown agents (65). These data corroborate the results of this study, showing the importance of adopting universal precautions during when handling all cadavers. However,it is important to evaluate each autopsy, and choose less hazardous methodologies, such as the diagnosis of viral hemorrhagic fevers using a skin fragment, or diagnosis of SARS using immunohistochemical methods or molecular biology ♠

Conflictos de interese: None.

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