INVESTIGATION TO IMPROVE CLEANING PROCEDURE ON POST-MORTEM TABLE FROM CROSS CONTAMINATION

by

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for the degree of
Master of Science (Forensic Science)

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CERTIFICATE

This is to certify that the dissertation entitled Investigation to improve cleaning procedure on post-mortem table from cross contamination is the bona fide record of research work done by Prakash a/l Manickam Kumarasamy during the period from March 2020 to August 2020 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted as a partial fulfilment for the degree of Master of Science (Forensic Science).

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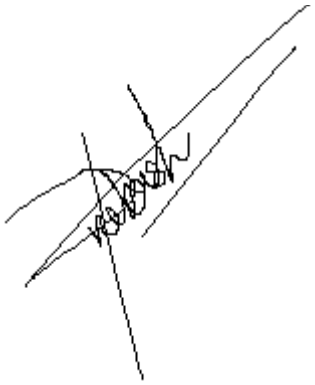
DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledge. I also declare that it has not been previously for concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.



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LIST OF SYMBOLS

+	Positive Result
-	Negative Result

LIST OF ABBREVIATIONS

PPE	Personal Protective Equipment
MOH	Ministry of Health
DNA	Deoxyribonucleic acid
EDTA	Ethylenediaminetetraacetic acid
HEPA	High Efficiency Particulate Air
PC	Positive Control
NC	Negative Control
FD	Fab Detergent
SDL	Sunlight Dishwashing Liquid
FDB	Fab Perfect Detergent Powder combination
	All Purpose Household Bleach

PENYIASATAN UNTUK MEMPERBAIKI KAEDAH PEMBERSIHAN MEJA BEDAH SIASAT DARI PENCEMARAN SILANG

ABSTRAK

Prosedur bedah siasat merupakan pemeriksaan rutin yang dilakukan oleh pegawai perubatan bertauliah di hospital untuk mendapatkan maklumat tentang punca kematian atau sifat kecederaan. Ketika prosedur bedah siasat, bahan bukti dikumpul daripada badan mangsa dan dihantar untuk analisis makmal. Selepas prosedur bedah siasat, meja bedah siasat mesti dicuci dan dibersihkan untuk memastikan tiada pencemaran ke atas prosedur yang seterusnya. Namun begitu, kebersihan meja bedah siasat boleh dipersoalkan dan keberkesanan prosedur pembersihan pada meja bedah siasat daripada pencemaran cecair biologi. Tujuan kajian ini adalah untuk menyiasat prosedur pembersihan yang berkesan pada meja bedah siasat daripada pencemaran silang. Dalam kajian ini, sampel darah buangan telah disapukan secara rata diatas keluli tahan karat bersize 2100 × 700 × 500 mm yang mewakili meja bedah siasat sebenar. Sampel darah pada permukaan keluli tahan karat dibersihkan pada pelbagai tempoh masa seperti 3 jam, 12 jam, 24 jam, tiga hari dan satu minggu. Empat prosedur pembersihan yang berlainan telah dilakukan, termasuk pembersihan dengan air sahaja, penggunaan bahan pencuci serbuk, penggunaan pencuci basuh pinggan mangkuk, serta gabungan pencuci serbuk dengan peluntur isi rumah. Selepas pembersihan, permukaan tersebut disampelkan dan diuji dengan ujian Teichmann. Daripada kajian ini, didapati pembersihan dengan cucian air sahaja adalah tidak berkesan dan menunjukkan pencemaran darah yang tertinggi berbanding dengan kaedah lain. Penggunaan bahan pencuci serbuk digabungkan dengan peluntur isi rumah adalah paling berkesan dan eksperimen telah menunjukkan tiada pencemaran silang dalam kesemua sampel yang diuji. Oleh itu, adalah boleh disimpulkan bahawa penggunaan bahan pencuci serbuk

dengan gabungan peluntur boleh memperbaiki kaedah pembersihan meja bedah siasat daripada pencemaran silang.Kaedah pembersihan yang bersih dan tiada kontaminasi diperlukkan untuk meenjamin keputusan analitik forensik yang boleh memberikan keputusan forensik yang berintergriti.

INVESTIGATION TO IMPROVE CLEANING PROCEDURE ON POST-MORTEM TABLE FROM CROSS CONTAMINATION

ABSTRACT

Post-mortem examination is a routine procedure carried out by a certified medical officer in the hospital to obtain information about the cause of death or the nature of injuries. During the post-mortem procedure, evidences are collected from the dead body and sent for laboratory analyses. After the post-mortem procedure, the post-mortem table must be washed and cleaned to ensure no contamination for the subsequent procedure. However, it is questionable on the cleanliness of the post-mortem table and the effectiveness of cleaning procedure from biological fluid contamination. The aim of this study was to investigate the effective cleaning procedure on post-mortem table from cross contamination. In this study, discarded blood samples were smeared evenly across a stainless-steel measuring 2100 × 750 × 500 mm size representing the actual post-mortem table. The blood samples on the stainless-steel sheet were cleaned at varying time elapsed such as 3 hours,12 hours, 24 hours, three days and 1week duration. Four different cleaning procedures were carried out, including water wash alone, usage of powder detergent, usage of liquid dishwasher, as well as a combination of powder detergent and household bleach. After each cleaning, the surfaces were sampled and tested with Teichmann reagent. From this study, it was found that cleaning by water wash alone was not effective, showing highest level of blood contamination as compared to other methods. Using powder detergent in combination with household bleach was the most effective and the experiment showed no cross contamination in all the tested samples. This can be concluded using powder detergent with combined of bleach can improve the cleaning methods of the post-

mortem table from cross contaminations. A clean and free contamination forensic procedure is important to establish analytical result which can upheld the integrity of forensic analyses

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Forensic medicine services utilise the principles of medical sciences to assist legal authorities in the adjudication of justice in accordance to the requirements of Malaysian Laws (MOH, 2012). When a person died in any instance circumstances, the body would be sent to the hospital for post-mortem to ascertain the cause of death. More specifically, the services in forensic medicine cover the management of death bodies brought to the hospitals, forensic post-mortem examination whenever required, assistance provided in relation to medicolegal inquires of deaths, as well as the management of forensic evidence in compliant with the chain of custody and law of evidence (MOH, 2012). Post-mortem examinations are conducted following the guidelines to ensure the professionalism, impartial and within the boundary of law and religion jurisdiction (Menezes & Monteiro, 2020). A certain post-mortem will be requested if there is a rise of doubt of any foul play in the death or the cause of death is not known (Menezes & Monteiro, 2020). Certain deaths are not required post-mortem such as patients who are given DNR (do not resuscitate) due to the nature of illness or patient who died in the hospital due to any known illness.

Mortuary services are provided by forensic medical experts. A post-mortem examination is principally carried out to obtain information regarding the cause of death or the nature of disease and injury. It also includes the retention of tissues removed during evidentiary, identification, diagnostic, scientific, or therapeutic procedures (MOH,

2012). Generally, there are two types of post-mortem examination, namely the forensic post-mortem examination and clinical post-mortem examination. The former is conducted to fulfil the legislation requirements while the latter is performed to obtain and expand knowledge in medical sciences. It is the duty of governmental medical officers to carry out a post-mortem examination, regardless of from the clinical or forensic aspects. Clinical post-mortems usually involve cases not under the investigation of police officers.

In crime scenes, dead bodies are frequently found. These dead bodies accompanied by the law enforcement authorities, particularly the police officers, are brought to the mortuary. For cases which do not require forensic post-mortem examination, these are cases with known cause of death and not fall for the police investigation under the Criminal Procedure Code Act 593. On the other hand, forensic medicine specialists will be informed for cases which require crime scene investigation as requested by the police officers (MOH, 2012). These are death cases involving police investigation or death with no known cause of death requiring forensic post-mortem examination.

In Malaysia, the special provisions under the Act 593 empower a police officer to investigate any reported deaths as stated in Section 329. If there is doubt or criminal conduct on reported deaths, the Section 330 empowers the police officer to refer the nearest government medical officer to carry out a post-mortem examination (MOH, 2012). Cases that frequently require forensic post-mortem examination include accidents, suicides, homicides, natural death, suspicious death, and sudden death. Referring to Act 593, the reports by medical officers regarding the post-mortem examination of a dead

body can be accepted as a prima facie evidence under the subsection 331 (2) (MOH, 2012). Through the post-mortem reports, police officers can obtain information about the cause of death or sources of injuries on the body of a victim, and subsequently relate to the weapon which could cause the death or even the suspect who involved in the criminal case.

During post-mortem procedure, evidence or biological samples are usually collected from the body and will be sent to be examined by the forensic, pathology, and toxicology laboratories to determine the cause of the death. Therefore, it is crucial to ensure the cleanliness of the post-mortem table so that no cross-contamination would be occurred during the post-mortem process from any previous activities, and directly affect the analytical outcome of the biological evidence. Most of the time the cleanliness and the sterility of the tools were taken much weightage compared to the post-mortem table (Gile, 2011).

This study investigated the source of contamination to be found in a mortuary before, during and after post-mortem procedure. The blood contamination on a post-mortem table which could lead to flaws in subsequent analytical procedures are covered. Safety and precaution recommendations to minimize the risk of contamination are also discussed in detail.

1.2 Problem of Statement

A postmortem table must be cleaned after a postmortem procedure. In the facility needs to be clear from any sort of contamination before a next postmortem procedure is conducted. This is particularly important to ensure the integrity of the forensic evidence.

An evidence must be free of any contamination during the investigation of forensic cases. Therefore, the cleaning procedure utilised by the hospitals, specifically the post-mortem mortuary, should be adequately effective in removing all the contamination. The effectiveness of various cleaning procedures remains unclear, deserving the needs for evaluation and assessment.

1.3 Objectives

General Objectives

To investigate the effective cleaning procedure from cross contamination in postmortem procedure.

Specific Objectives:

i. To compare the effectiveness of cleaning procedure between usages of different detergents and using normal water wash only.

ii. To determine the cleanliness of simulated postmortem settings with different time elapsed upon cleaning procedure.

iii. To suggest ways to improve the current cleaning procedures which practiced in Ministry of Health of Malaysia.

1.4 Significance of study

This study would aid in determining the effectiveness of cleaning procedure on post-mortem tables and minimizing the risk of blood contamination on the forensic evidence. Subsequently, the suggestion of the most suitable cleaning procedure could aid in maximizing the forensic values of biological evidence for not being tampered by any potential contamination from the surface of postmortem table. Additionally, the cleanliness must also be maintained to minimize the possibility of infection to the personal involved.

CHAPTER 2

LITERATURE REVIEW

2.1 Source of contamination in mortuary

There are different contaminations which could be arisen from autopsy procedures. These contamination affects the forensic analysis and it gives different results. The cross contamination can manipulate or gives false results during the court trial which can leads to injustice. The contamination is mainly chemical contamination, biological contamination which can be due to microbes and mixtures of bodily fluids, DNA mixtures (Davison, 2000),radiation contamination, as well as human contamination. In forensic medicine and forensic science services, contamination must be avoided and proper identification of the sources of contamination must be ensured. The effectiveness of cleaning the apparatus and post-mortem table must be maintained in all time.

2.2 Biological Contamination

During autopsy, biological contaminations are the major disaster accounted by the forensic personnel. Microbes plays a vital part as it cannot be visualized by naked eye. There are several high risks of hazards that the health workers in the autopsy room can be exposed, including pulmonary tuberculosis, Human Immunodeficiency Virus (HIV), as well as Hepatitis B which appear in the form of microbes during a post-mortem procedure (Kadam & Akhade, 2015). For forensic laboratory analysis, samples are taken by swabs from the post-mortem table, draining board, irregular instruments and cultured on nutrient blood agar which was noted to be heavily contaminated (Kadam & Akhade, 2015). The samples are tested prior an autopsy procedure and noted to have lesser contamination compared to during and after an autopsy procedure. The usages of gloves

and apron are also accounted for heavy contamination of bacteria (Kadam & Akhade, 2015). If these materials are not be disposed properly, they will become one of the major causative infection for the involved personnel due to increase of contamination levels during the post-mortem procedure (Kadam & Akhade, 2015).

Apart from microbes, DNA can be transferred from the previous dead body or foreign sourced to the current bodies when cleaning of the table after post-mortem procedures are not be conducted correctly. It is a forensic challenge when these types of contaminations can be questioned when exogenous DNA are being found. Study was conducted where DNA samples were swabbed using Invisorb Spin Swab Kit and phenol-chloroform DNA extraction methods from tooth forceps and the post-mortem tables (Maxwell hove, 1998). The utilization of real time PCR showed that there was significant level of DNA detected from the post-mortem table and suggested the presence of external DNA (Schwark, 2012). Besides, there are transmissions of bacteria's such as Mycobacterium Tuberculosis and anthrax which can be deadly for the medical personals who involved in autopsy procedure (Kadam & Akhade, 2015). In terms of the tuberculosis infection, the usage of surgical masks proved to provide insufficient protection to the personals. For those involved with the tuberculosis patient are requested to wear N-95 respiratory a High Efficiency Particulate Air (HEPA) masks (Kumar, 2013) as the disease is airborne and infectious.

2.3 Chemical Contamination

Chemical contamination could be encountered in most cases during postmortem procedure. The usages of formaldehyde during the handling of formalin-mixed organs or specimens which are not washed properly could give rise to irritants on mucous

membrane such as the skin, eyes and in long term it can cause all types of cancer (Toom, 2012). It can also give rise to acute irritations and chronic results including laryngitis and bronchitis (Health, 2010). In another review article (Ogrodnik, 1986), formaldehyde was found to have no high degree level of systemic toxicity, but it could lead to allergic and eye irritants. It could worsen pre lungs conditions of the workers and they were advised to have limited exposure to 1 ppm concentration level of formaldehyde in less than 30 minutes.

Additionally, (Kamanyire, 2013) discussed contaminated dead bodies due to the ingestions of chemicals by the dead through self-poisoning or industrial accidents. The main components of the chemical contamination were a mixture of inhalations and ingestions of toxic compounds, mainly domestic cleaners. The other potent chemical contaminations are from cyanide poisoning where it can be inhaled, ingested as well as through intact skin. Personnel who had performed an autopsy on chemical contaminated bodies, such in a person who ingested cyanide, is exposed to high risk. A blood cyanide concentration could be elevated to 38.4mmol/L (1mg/mL) where the normal level is 7.6mmol/L (Kamanyire, 2013). Other than cyanides, colorless and flammable hydrogen sulfide could also produce significant death. Industrial exposure to such chemical had accounted for risk of chemical contamination to the personnel who performed the autopsy and the first responder. However, it was noted that the risk was lesser in the former as compared to the latter. The chances of contamination in the postmortem room was probably due to the saturation of gas prior to death, and the gas released during postmortem procedure could subsequently affect the medical personnel (Kamanyire, 2013).

2.4 Air Contamination

Air contamination is a contamination which is least taken into consideration. As a postmortem procedure always involves personnel in healthcare system who had followed the standard operation procedures by wearing the proper personal protective equipment (PPE) and using sterilized equipment, they are still exposed to the air contamination. According to Lean Middle East (2011), air samples tested using Biomrieux Air Ideal Biocollector, investigating 250 L of air sample twice a day, showed that one of the culture dishes contained a non-selective bacterial growth medium (i.e. Trypticase soy agar), and another sample was detected with sulfite-reducing anaerobes. It was reported, there were environmental saprocytes found before a postmortem procedure, and an increased median of saprocytes not exceeding 1 CFU per 250. The study signified the presence of bacteria before and after a post-mortem procedure.

Inhalation of aerosols produced by water hose and saws used for autopsy procedures was reported to have contributed to air contamination (Perdelli, 2008). Additionally, highly toxic formaldehyde agent can cause cancer as well there are also exposure of cyanide gas from the person who had died ingesting cyanide (Clark, 1983). Apart from that, organophosphate phosphates such as malathion and certain nerve gas can diffuse into PPE worn by the personnel involved in the postmortem procedure. These conditions could be prevented if the standard of operating procedures was implied in the medical laboratories applies to the autopsy room as well (newsom, 1983). A study using Casella slit sampler showed that the number of microorganisms is higher in those forensic medicine facilities with poor air ventilation and large occupancy of personnel as

compared to good ventilated room with less individuals (Jrbabb, 1989). The main air contaminations noted in this study was arisen from the death on individuals who died due to septicaemia with infarcted bowel, and the postmortem procedure was conducted in the poorly ventilated room with high level of readings in air contamination (Perdelli, 2008).

2.5 Potential contamination and degradation of forensic evidence

Forensic evidence is important to ensure the modus operanti and the cause of death of victim for a forensic case are determined. It is valuable to establish the key elements of a criminal activity, determining individual at a scene during the crime, exonerating innocent defendants, as well as corroborating the testimonies of the victims, suspects, and witnesses. Therefore, all the personnel involved in a forensic investigation must cooperate and provide the best level practice to solve a crime, and subsequently bring a criminal to the court. However, there are instances where failure to adhere to standard protocol chances of contamination on the forensic evidence during the investigation process from crime scene to mortuary or laboratories can happen.

2.6 Residual DNA background

On the various surfaces in mortuaries or laboratories, the presence of background DNA could be evident due to previous contact or subsequent transfer (Poy & van Oorschot, 2006a; Vandewoestyne *et al.*, 2011; Ballantyne *et al.*, 2013; Meakin & Jamieson, 2013). Such contamination refers to any DNA introduced to the evidentiary material after a crime has been committed (Gill, 1997) The presence of such DNA sources can out-compete endogenous DNA in PCR amplification, thus leading to false positives and/or atypical results. There are circumstances where background DNA may be introduced into the samples, namely from the field or crime scene through handling,

from the laboratory or mortuary personnel, due to cross contamination between case samples and PCR products, as well as the existence of pre-packaged laboratory reagents or had been present on labware.

In fact, the maintenance of high standards within the forensic laboratory and the mortuary could minimize the sources of contamination (Cooper, 2000). The failure to adhere to the standard cleaning procedure had contributed to the presence of residual contamination on these (Szkuta, 2015). More severely, the human behaviours involving the defective decontamination procedures might also lead to the existence of DNA on any surfaces in which such procedures did not successfully removed the contamination (Rutty *et al.*, 2000; Ballantyne *et al.*, 2015). Toledano *et al.* (1997) reported that the structural facilities of mortuary rooms could have contained potential accumulation of human DNA, and therefore lead to the possibility of DNA contamination. From (Rutty, 2000) investigation on 20 mortuaries (2000), 50% of them were found to have contaminants with quantifiable human DNA on the instruments or surfaces. More recently, DNA was recovered from samples collected from the instruments used during the post-mortem and the table, and they are likely to be linked to the dead bodies autopsied previously (~~T.~~Schwark, 2012)

In forensic investigations as well as post-mortem procedure, the forensic laboratories and mortuary are often presented with source of DNA contaminants which had been directly or indirectly handled. It is of importance from every involved personnel to aware on the problems of contamination. The laboratories supplies were reported to have contained certain amount of DNA which could cause false positive results on laboratory analyses or lead to results misinterpretation (Szkuta et al., 2015; Daniel & van

Oorschot, 2011). Getting items or reagents guaranteed to be DNA-free can aid in minimizing the source of contamination (NIJ, 1999). Even if brand new instrument or apparatus is used, the completely free of DNA might not guarantee the user. It was always recommended that gloves of personnel handling exhibit, especially for those samples taken for DNA analysis, should be regularly changed.

Additionally, the contact with areas of exhibit that are likely to be sampled from DNA analysis should be avoided, and the tools and apparatus that in contact with these exhibits should be regularly and thoroughly cleaned (Oorschot, 2011).Such precautions should be taken particularly for cases containing very trace amount of DNA through regular review on the source of consumables and their adherent to the standards. Any contaminations must be avoided by securing traces from a crime scene, especially a death scene, though the usage of recommended disposable equipment. Besides, regular monitoring and quality control procedure should be performed on all consumables for the determination of the level of DNA, if present (Ballantyne et al., 2013).

The source of background DNA may not be apparent to the human eyes in most instances, and thus work areas and instruments may appear ‘clean’. If contamination is detected, the determination of the source of contamination can be very costly and time-consuming. Certain laboratory analyses need to re-run to confirm the results and detect the contamination. Furthermore, comparative DNA profiles of all the involved personnel within a case are nearly non-existed (Rutty, 2000). In more severe cases, the contamination of DNA profiles could lead to the wrongly conviction or expel of forensic cases.

2.7 Effectiveness of cleaning procedure

With various types of contamination could be encountered in hospital and laboratory settings, different cleaning methods have been discussed based on the nature of occurrences. The general proposes of cleaning are to reinstate and preserve the originality, as well to reduce the corrosion. In the current cleaning method which was used by the ministry of health, the usages of only water wash and powder detergent and disinfectant, it is useful against biological (Dancer, 2003), chemical, human errors as well as air contaminations (~~B.~~Hill, 1988) .

A suggested cleaning procedure using hand hygiene care and reviewal of cost-benefit standards was proposed (Dancer, 2003). According to the Griffith (2000), ATP bioluminescence assays can be used to differentiate between microbial and non-microbial when improved Biotrace Multishot was used. Overall visualization of the surface in terms of dirt or stains and a microbiological evaluation was carried out using standard proforma. Two different agars used to differentiate enterobacteria and staphylococcus were pressed against the regular surfaces such as tables and chairs, and subsequently the colonies, if any, were inoculated and studied. For irregular surfaces such as apparatus, sterile pre-moisten cotton wool swab was used to thoroughly swab the surface, inoculated, and visualized for the presence of microbes. Two different time durations were tested, namely before and after best practice of cleaning. The cleaning involved the use of sanitizer containing ionic surfactant and sodium hypochlorite, followed by rinsing with water. The study showed that lower number of bacteria was found in the wards as compared to the trolley hand. Additionally, ATP bioluminescence was preferred from normal visual examination and microbial approach due to the inability to verify the presence of bacteria simply by naked eyes (Malik, 2003).

Blood contaminations can be detected using presumptive and confirmatory test. The presumptive tests are such as leucomalachite green (LMG), phenolphthalein and luminol (Dancer, 2003). By looking into different kind of substances which varies in forms of organic and inorganic compounds, there are a lot of possibilities for a reagent to get tested false positive especially with those less-sensitive tests. Various cleaning procedures which had been routinely done were studied to assess the quality of the cleanliness of postmortem table. Hospitals have reviewed a strict protocol on cleaning the postmortem table, equipment and postmortem facilities, as well as the bodies of the dead (Board, 2014). It was suggested that all the surfaces should be cleaned with 1 in 49 diluted bleach (mixing 1 part of 5.25% of bleach with 49 parts of water) and it must be dried for 30 minutes duration before it is washed with water. Metals surfaces used or to be used must be wiped with 70% alcohol. It was also specifically stated that any instruments or metal surfaces that are visibly contaminated with blood and body fluids must be washed with more concentrated bleach mixtures, corresponding to 1 part of bleach which is 5.25% to be mix with 4 parts of water, allowed it to dry for 10 to 30 minutes before washed with water. The bleach solutions must be freshly prepared before any washing to make sure the recommended concentration is followed.

As described previously, bleach used to remove DNA was much passable as compared to simply washing using soap and water in most instances. Apparatus incubated with bleach after washing with soap and water wash had reported with very similar results as using the bleach; however, the procedure cannot be carried out on the post-mortem table. Due to the probably contamination from the postmortem table, such surfaces might not be adequately cleaned by bleach, resulting susceptible DNA cross

contamination as compared to postmortem table which was washed using all three entities, namely the bleach, soap, and water wash (Toom, 2012).

Certain materials and methods had been discussed in Balk (2015), where it clearly stated that bleach allowed the achievement of fully cleanliness. In other words, bleach can permanently remove DNA residues from the postmortem table. No cross-contamination of DNA could be evident on the cleaned surfaces, but the cleaning procedure must be done intermittently. Thus, by having a complete and thoroughly wash with a mixture of detergents and bleach, cleanliness of a postmortem table can be maintained. There are evidences that supported DNA contamination from a previous dead body when a new body is placed for an autopsy which suggesting the standard operating procedure is not reviewed systematically. This can affect the analytical results when presented in court as encountering an external DNA might tamper the purity or accuracy of the results (Geddes, 2012).

2.8 Residual cleaning solution

As a commonly used cleaning solution, sodium hypochlorite can minimize contamination on tools or any surfaces in mortuaries or laboratories (Szkuta, 2015) Although it had been proved with its effectiveness in decontamination at certain concentration levels, the residues from a cleaning solution or upon a cleaning procedure could remain on a surface, either on a mortuary tabletop, laboratory tools or equipment. If the residual cleaning solution possesses the detrimental effect to degrade the DNA profiles, it might lead to wrongful analytical results. The effect of residual hypochlorite was investigated by (Szkuta, 2015) when usage of 10% hypochlorite solution and subsequently air-dry a surface showed the degrading effect on the DNA quantity and

DNA quality where it destroys the DNA wholly as the component of DNA is alkaline and the acidic part of the bleach able to destroy the exogenous part of DNA. Based on the study, rinsing of cleaned surfaces with water following application was (Szkuta, 2015)In mortuary and forensic laboratories, constant review of the cleaning agents, methods, and procedures, especially their frequencies and timings would aid in minimizing contamination (Ballantyne et al., 2013).

2.9 Transfer from the apparatus and equipment

During the sampling or the collection of forensic related samples from a dead body, the personnel in the mortuary requires the use of certain tools, apparatus, or equipment. For example, criminal acts involving sexual assault or homicide always need to undergo post-mortem examination by the forensic medicine specialists. During the procedure, samples would include nail clippings for the laboratory analysis of any material potentially to be found underneath the nails. In some cases, the DNA profile of the perpetrator could be determined through any skin fragments and blood found on the nail. In routine procedure, the nails must be cut close to the skin from each hand and packed separately. Besides, the head and pubic hair were combed onto collecting paper and packaged into properly labelled bag (Sheaff & Hopster, 2005). In such cases, nail clippers and comb had been used for the collection of important forensic evidence. However, if the tools had been contaminated with residual DNA or not thoroughly cleaned before the application, the chance of its transference to the samples recently collected is high and influence the analytical outcome in the forensic laboratories (Sheaff & Hopster, 2005).

2.10 Methods used in testing presence of contaminations

In the aspects of any cross contaminations, certain tests can be done to determine the presences of external sources in view of biological, chemical or any other sources. The most important part in biological contamination is to differentiate the presence blood is from human or from other species. Presumptive test can determine the possibility of certain bodily fluids presence while confirmatory test is done to identify the material. These tests are crucial in analysis of the forensic. Other types of biological contaminations are urine where presumptive test is DMAC, for saliva is alpha-amylase test.

2.10.1 Presumptive Tests

Presumptive test is used to identify blood material through several test such as Phenolphthalein Test aka Kastle-Meyer test, Luminol Test and Alternate-Light Sources. The test is usually done first, followed by confirmatory test. Kastle -Meyer test shows the presences of hemoglobin through the break down reaction of phenolphthalein reagent to phthalein by zinc and regenerated by oxygen liberated from hydrogen peroxide from haemoglobin. The solution must be alkaline in reaction and shows reddish colour. This test is very delicate where it can mimic errors from other sources (Glaister, 1926).

There are literature reviews showed usages of alternative light source such as ultraviolet light could damage the DNA evidences, thus the luminol test was preferred and used over 40 years to test the presence of hemoglobin (Kelly Virkler, 2009). The test is preferred due to its harmless compared to other chemical reagents (Kelly Virkler, 2009). In the parallel test, fluorescence techniques used to determine the reaction between heme and oxidation of fluorescein to fluorescein peroxide is observed but it is not

commonly used. The method is not favorable due to its need of exposure to an alternative light source with a wavelength of 425 - 485 nm.

In the review of conducted by Lee (1978), it was discussed that colour catalytic are very sensitive, but the results are not specific towards the target substance. Therefore, the detection of color might not specifically demonstrate the presence of blood. There are chances of false positive where it could show positive results other than blood when it interacts with certain groups such as chemical oxidants and catalysts groups which has copper and nickel, plant sources vegetables such as dandelion root can be mistaken for blood. For example, tomato may react with tetramethylbenzidine and showed positive results for blood and animal origin (Lee, 1978)

2.10.2 Confirmatory Tests

There are few confirmatory tests that can be done to ascertain presences of blood when any contamination is suspected, but it is time consuming and needed large blood samples which is tedious to be done in the crime scene itself. To ascertain the properties of blood weather it is a human blood or blood from other origin is very crucial. These tests can help in the outcome of the forensic analysis because during a court trials, the question of the blood from human or animals or other origins are usually important.

2.10.3 Inhibition of human antiglobulin

In the review of (Almeida, 2011) described the usage of inhibition of human antiglobulin on samples using physiological buffered saline with added of antihuman globulin. Subsequently, the sample was incubated for 45 minutes and finally two drops of previous sensitized anti-D antibody Rh_+ suspension was added. The sample was then

incubated for 15 minutes and centrifuged at 13,000 rpm for 15 seconds. The samples which showed no agglutination can be considered positive for human blood (Almeida, 2011).

2.10.4 Precipitin Test

In other studies, for identification of blood, precipitin test could be done. It is due to the properties of the proteins in the human serum or whole blood, even if it is an insipid solution, the sample could be triggered by homologous and species-specific antiserum. By performing the tests through inhibition of the indirect Coombs test with series of different level of dilutions, the results showed the inhibitory effects at nearly same inversely proportional outcome to the usage of human serum (Jonathan, 2005). On the other hand, they demonstrated slight or no agglutination at all for the animal blood. These results are not only blood specific but also organ specific (Morton, 1953).

2.10.5 Human hemoglobin immunochromatographic test

Literature also described the possibility to identify human blood by human hemoglobin immunochromatographic test (Puritan, 2016). This test was done by inserting the samples in a 1 mL of Tris EDTA with the pH of 7.5. The sample was then soaked into the 150 mL of buffer solution and tested with the Hexagon OBTI strip where indication of two blue line, one at control positive and one in test positive showed that the sample is a human blood (Almeida, 2011).

2.10.6 Takayama Test

Takayama test which contains glucose like non other reagents, the stains will change its colour from brown to red and begin to be crystalized soon after the cooling

(Shevchenko, 1998). The visualization of crystals under the microscopes could confirm the presence of blood. In certain occasion, it could give a false negative result if in the experiment, ammonium-sulphide was used instead of glucose which can mask a cherry -red colour of the hem chromogen crystals (Li, 2011).

2.10.7 Teichmann Test

In the other hand, Teichmann test which is the oldest method is still preferred due to its simplicity method (Shevchenko, 1998). It is known that the hemin in the blood which is the prosthetic group of haemoglobin can be visualised in crystal form when the blood is heated up while mix with a concentrated acetic acid which will then visualised by microscope and rhomboidal structure of crystal proves the presences of blood (Kobilinsk, 1984).

2.10.8 Raman Spectroscopy

Raman spectroscopy can differentiate the species of blood from human and animal. Animal blood from cow, cat, dog, horse, pig, mouse, opossum, racoon, rabbit, rat and chicken, as well as from the human blood was taken and tested using a chemometric PLS-DA model based on the Raman spectral data (Gregory, 2014). In this study, internal and external validation were carried out and the results showed no false positive and clearly interpreting the species (Gregory, 2014). Other than that, a self-reference algorithm was also used to discriminate human and nonhuman blood samples. The classification of the ratio between two Raman peaks could aid in confirming the blood species. The study showed that Raman spectra of human to non-human blood was 1341cm^{-1}, indicating that the chemical composition of tryptophan (C-H bend) was a major factor to discriminate that small between human and non-human bloods (Haiyi Bian, 2017)

2.11 Safety and precaution recommendations

Due to the mortuary and its working facilities are restricted areas, entry to such premises shall only be allowed by the authorization and with supervision. The number of people accessible to an autopsy room should be only restricted to those directly involved in post-mortem procedure (Tsujimura, 2017). In fact, all dead bodies are potentially infectious; therefore, strict precautions must be followed by the health personnel involved in handling cases that require mortuary services. Although a dead body is unlikely to infect health individuals, some infectious agents may be transmitted if a person have contacted with blood, body fluids, or the tissues of the dead body of a person carrying infectious diseases (Tsujimura, 2017)To minimize the transmission risks of known or unexpected infectious diseases, dead bodies must be handled with precautions and following the standard procedures.

A mortuary and post-mortem facilities pose health and safety risks (NHS Scotland, 2002), including

- Infection risks (e.g. exposure to infectious agents arisen from dead bodies, aerosols or body fluids) which can infect the breathing problems.
- Physical risks (*e.g.* accidents or injuries due to use of equipment or heavy load or injuries due to sharp apparatus, bone fragments and any surfaces within a mortuary, as well as slipping or falling due to the presence of fluid on the floor).
- Chemical risks (*e.g.* accident or exposure to noxious chemicals, fixatives, solvents, and disinfectants) which can cause serious respiratory problems
- Electrical risks (*e.g.* electrocution arisen from contact of water with electricity)
- Radiation risks (*e.g.* exposure to radioactive materials upon usage for diagnosis or procedure, as well as the possible radioactive materials from dead bodies)

A mortuary must always be kept clean. It should always also exist in proper ventilation environment with adequate lighting (NHS Scotland, 2002). Post-mortem table is the main place where post-mortem examination is conducted. It must be cleanable and free from any trap for potential infected material. All surfaces and instruments should be made of easily disinfected and maintained materials. As described in the previous section, post-mortem tabletop which may be contaminated with blood or body fluids should be wiped with household bleach, leave it for 15 minutes, and then rinse with water (Department of Health, Hong Kong, 2020). For metal surfaces, they can also be wiped with 70% alcohol. If a surface is visibly contaminated with blood and body fluids, a more concentrated household bleach can be used, usually at a 1:4 ratio (Environmental, 2018). It was recommended that freshly prepared bleach solution should be used for the cleaning purpose. Besides, sodium hypochlorite solution was also reported as cleaning reagent is common practice among many laboratories to minimize contamination (Szkuta, 2015) .

It was recommended that compartments for the storage of dead bodies should be easily accessible for the purposes of regular cleaning and maintenance (Abel, 2015).Besides the main post-mortem table, the environmental surfaces, instruments, and transport trolleys should not be overlooked and must be properly decontaminated. All the waste management must also refer to the hospital clinical and chemical waste management procedures according to the legal requirements. For safe waste disposal, a clear segregation and appropriate containment for wastes of different types are also necessary (Abel, 2015).In addition to post-mortem examination, the proper management of forensic evidence and specimen is very crucial for forensic investigation (MOH, 2012). Such evidence refers to body tissues or body fluids collected during the post-mortem examination for laboratory analysis. This proper management is important to

ensure the course of forensic examination has maintained the chain of custody (MOH, 2012). All such specimen must be collected in appropriate container and submit to relevant laboratories in accordance with the standard precautions.

As forensic post-mortem examination involves dead bodies, the control of contamination of deoxyribonucleic acid (DNA) evidence on the body of decreased is of importance to ensure the integrity of the forensic evidence (MOH, 2012). All procedures performed in the mortuary, including the handling of dead bodies, collection of forensic specimens, post-mortem procedure, as well as the cleaning of post-mortem table, must follow strictly to the standard precautions. Therefore, all equipment and the post-mortem table must be in very clean condition prior to placing the dead body on the table. Whilst still in the body bag, the dead body shall be examined and took photograph if needed. Besides, the clothing from the body should also be removed while the dead body is still placed inside the body bag and packed into separate packaging papers. During post-mortem examination, every single apparatus used must be sterile and clean. After the examination, the body will be released depending on the cases. Based on the standard of procedure released by Ministry of Health Malaysia, the cleaning procedure must be performed before and after each post-mortem examination (MOH, 2012). Figure 1.1 illustrates the flowchart of control of contamination of DNA evidence on the body of the decreased. Note that the control of contamination of DNA evidence is crucial in forensic cases to avoid any flaw in forensic subsequent analyses.

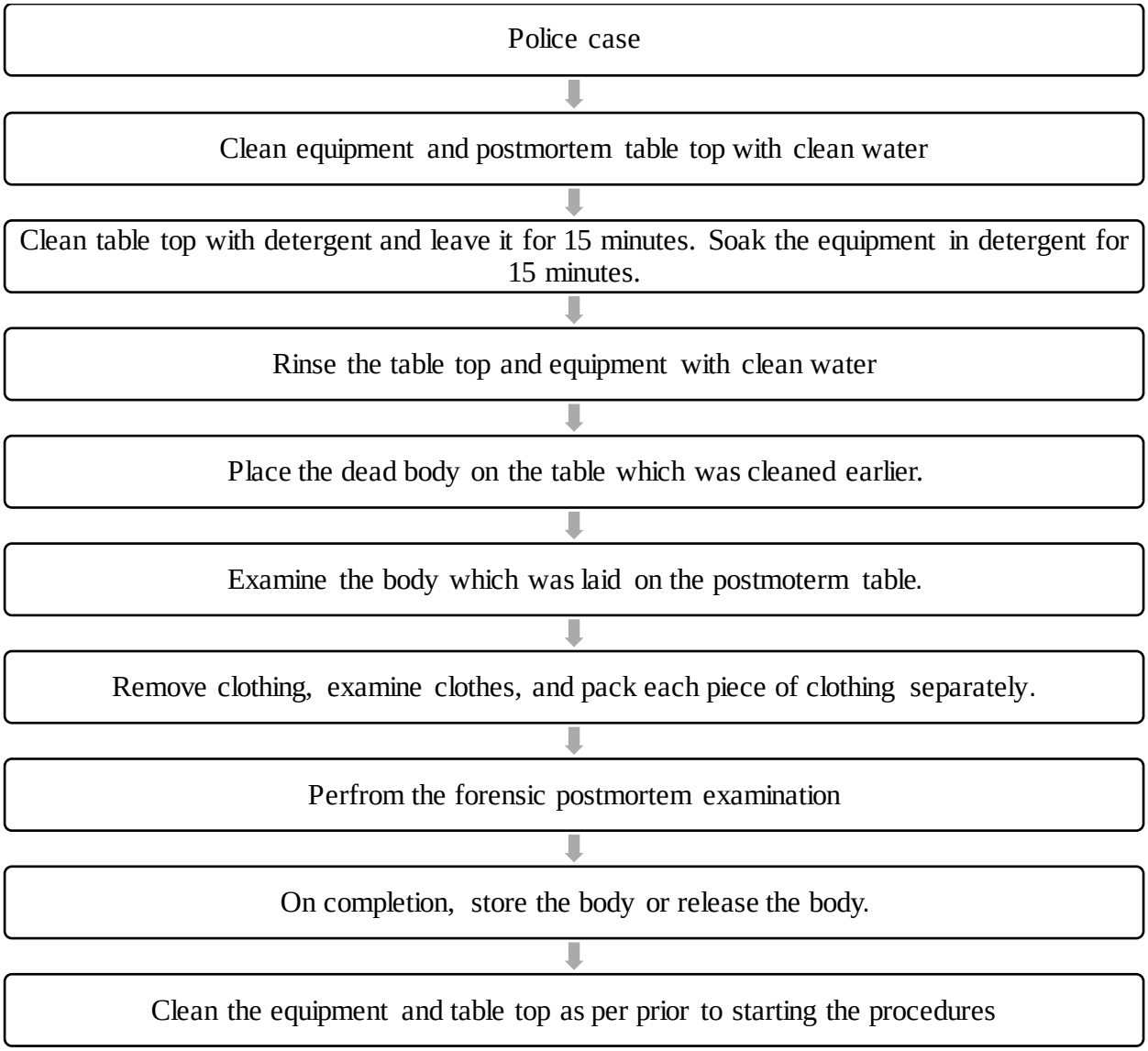

Figure 1.1: Flowchart of control of contamination of DNA evidence on the body of the decreased (MOH, 2012)

Lastly, the awareness education for all the involved personnel from the crime scene, to mortuary, and subsequently to forensic laboratories should be increased, with the enhanced sensitivity of DNA typing and profiling applications (Ballantyne et al., 2013). Vaccination is recommended for all personnel involved in the post-mortem examination and procedures (Department of Health, Hong Kong, 2020). Additionally, all personnel should be trained in minimising the risk of disease transmission and prevention of infections. Direct contact with blood or body fluid should be avoid in all instances,