International Journal of A J Institute of Medical Sciences 1 (2012) 67-74

Review Article

Biomedical waste management

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Abstract

Biomedical waste is defined as the waste generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological, and including categories mentioned in schedule I of the Biomedical Waste (Management and handling) (second amendment) Rules 2000, by Ministry of Environment and Forests notification. Proper handling, treatment and disposal of biomedical wastes are important elements of healthcare infection control programme. There may be increased risk of nosocomial infections in patients due to poor waste management which can lead to change in microbial ecology and spread of antibiotic resistance. It is not only the health of the patient, but also the health of persons in health care industry equally important. This article speaks about how to treat and dispose the biomedical waste, and its legal aspects.

Keywords: Biomedical waste (BMW); Waste management; Legal aspects

Article 17th March, 2012; Revised 25th March; Accepted 3rd April, 2012.

1. Introduction

Biomedical waste is generated in different departments of the hospital and college, research institutions, healthcare teaching institutes, rehabilitation centres, clinics and nursing homes, laboratories, blood banks, autopsy centres, animal houses, veterinary institutes and at home if healthcare is being provided there to a patient (e.g. injection, dressing material etc.). The waste produced in the course of healthcare activities carries a higher potential for infection and injury than any other type of waste.[1] The last century witnessed the rapid mushrooming of hospitals in the public and private sector, dictated by the need of the expanding population, and the advent and acceptance of disposables has made the generation of hospital waste a significant factor in present hospitals. If we do not learn the methods of disposing the waste generated in the process, the 'treatment' will cause the disease. Then the very purpose of the medical inventions and scientific research will be defeated. There is a duty to see that the medical waste will not develop into a monster taking away the fruits of centuries of research and pushing the creatures into disaster.

In healthcare settings, about 85% of the waste generated is non-hazardous and 15% is hazardous, of which 10% is infectious and 5% non infectious. If the infectious components get mixed with the general infectious wastes, the entire mass becomes potentially infectious. Thus hospital waste generation has become a prime concern due to its multidimensional ramifications as a risk factor to the health of patients, hospital staff and extending beyond the boundaries of the medical establishment to the general population.[2,3] Although very little disease transmission from medical waste has been documented, the Center for Disease Control recommended that medical waste disposal must be carried out in accordance with regulations.[4] The evolution of a separate category of medical waste within the municipal waste stream dates back to the late 1970s, when medical wastes, including syringes and bandages were washed up on beaches in the along the Ease Coast of USA. The public outcry that followed led to the formulation of the US Medical Waste Tracking Act (MWTA), which finally came into force on 1st November 1988. [5]

In a study conducted in Gujarat in government and private hospitals, it was observed that not a single doctor knew about the various categories of biomedical waste. In the same study it was observed that 26% of doctors, 43% of paramedical staff did not know the risks associated with biomedical waste. Most of the hospitals were not disposing biomedical waste according to the guidelines; none of the hospitals had any record keeping system about the amount of waste generation.[6] It is high time that the subject is included in the curricula of medical education.

2. Discussion

Objectives of biomedical waste management are to prevent transmission of disease from patient to patient and among healthcare personnel, along with prevention of injury and to prevent exposure to the harmful effects of the cytotoxic, plastic and chemical waste.

2.1 Classification of hospital waste [2,7]

The following classifications of waste were adopted by the Department of Health as guidelines for all healthcare facilities:

1.**Pathological wastes** consist of tissues, organs, body parts, human fetuses, blood and body fluids from different specialties of hospital.

2.**Infectious wastes** include cultures and stock from laboratory, wastes from surgery and autopsies, from patients in isolation wards, from patients undergoing haemodialysis.

3.**Sharps** include needles, syringes, scalpels, saws, blades, broken glass, nails and other items that could cause a cut or puncture.

4.**Pharmaceutical wastes** include pharmaceutical products, drugs and chemical that has been returned from wards.

5.**Radioactive wastes** include solid, liquid and gaseous waste contaminated with radionuclides.

6.**Chemical wastes** include disinfectants (hypochlorite, glutaraldehyde, iodophors, and phenolic compounds).

2.2 Health hazards associated with poor hospital waste management

The effect on general population is mainly through acute exposure and chronic occupational exposure in the healthcare industry. Injuries from sharps to all categories of hospital personnel can transmit dangerous infections by HIV and HBV. Disposable, recycled, repacked biomedical wastes may be responsible for transmission of diseases. The average rate of generation of biomedical wastes in India varies from 1 kg to 5 kg per bed per day.[8] Though the major hospitals and healthcare establishments have started implementing waste management systems, there are a number of healthcare establishments, which dump their wastes in the municipal garbage dumps. In the case of open dumping sites with open borders, wastes and their emissions are directly discharged in to the

natural medium. This increases the contamination spread by air circulation and superficial and ground water flows and the health risks are increased due to humans and animals having access to the site.

Highly infectious diseases transmitted by direct or indirect contact with infected clothing, body secretions include cholera, rabies, tetanus, poliomyelitis, mumps, septicemia, typhoid, tuberculosis, hepatitis, human immuno deficiency syndrome, encephalitis, and meningitis.[9] Risk of transmission of HIV can occur through needle prick injury during collection of blood and other body fluids, mucosal splashes, and skin contact with superficial injury during autopsy on a HIV infected body. Risk of viable HIV has been recovered from blood samples up to 16 days after death.[9] The drainage of water, blood, body secretions which necessarily evolve during the process of autopsy is also not good, spilling out on the floors most of the times exposing the doctors, helpers to infectious diseases.

2.3 Biomedical waste storage and transportation

The key to minimization and effective management of biomedical waste is daily collection, identification and segregation, mutilation, disinfection, storage, safe transportation of waste to off site treatment facility and final disposal with suitable technology.[2] The most appropriate way of identifying the categories of biomedical waste is by sorting the waste in to color coded plastic bags or containers in accordance with rules as mentioned in table 1 and table 2.[10] Following this rules can decrease directly and indirectly health risk to people, and damage to flora, fauna and the environment.[11]

The waste may be temporarily stored at the central storage area of the hospital and from there it may be sent in bulk to the site of final disposal once or twice a day depending upon the quantum of waste. As per the rules, biomedical waste can not be stored for more than 48 hrs. The infected waste that can not be incinerated (e.g. plastic, rubber materials, sharps) has to be disinfected first. During transportation care should be taken i.e. containers are properly sealed and labeled, kept only in a specified storage area, clean the container with an appropriate disinfectant after removal of bag. Transportation from hospital to the site of final disposal is in a closed motor vehicle (truck, tractor-trolley etc.) is desirable as it prevents spillage of waste. Vehicles used for transport of biomedical waste must have the "Bio-hazard" symbol.

The liquid pathological waste should be treated first with a chemical disinfectant to neutralize it and can be flushed into the sewer system. All specialities of hospitals must have adequate, good drainage facilities so that the infected body fluids or liquid wastes can be drained without causing much problem to the public and healthcare personnel. The mortuaries must have good storage facilities for organ preservation with proper drainage system. Supply of proper autopsy dress in medico legal centres minimizes the risk of exposure to biomedical waste in doctors and helpers. During conduction of autopsy in medical negligence cases, removal of Ryle's, endotracheal, drainage tubes, catheters, splints etc must be done properly and treated according to the guidelines. Human tissues, organs, body parts, animal tissues, bleeding parts, fluid, blood and experimental animals are to be treated with incineration or deep burial.[8] Chemicals used to treat the autopsy waste stream may include chlorine (sodium hypochlorite) lime (calcium oxide), and soda ash (sodium carbonate).[12]

2.4 Chemicals used for disinfection

1. Phenol and related compounds like lysol, cresol, chlorhexidine, dettol.

Table 1: Categories of biomedical wastes and methods of their disposal

Category	Waste type	Treatment and disposal method
1	Human wastes (tissues, organs)	Incineration/deep burial
2	Animal waste	Incineration/deep burial
3	Microbiology, biotechnology waste	Autoclave/microwave/incineration
4	Sharps	Disinfection/autoclaving/microwaving/ Mutilation shredding
5	Cytotoxic, discarded drugs	Incineration/drugs disposal in secured landfills
6	Contaminated solid waste	Incineration/autoclaving/microwaving
7	Solid waste (other than sharps)	Disinfection/microwaving/autoclaving
8	Liquid waste (generated from laboratory procedure)	Disinfection and discharge into the drains
9	Incineration ash	Disposal in municipal landfill
10	Chemical wastes	Chemical treatment and discharge in to drain for liquids and secured landfill for solids

Table 2: Colour coding, treatment option for various types of biomedical wastes

Color coding	Type of container	Waste category	Treatment option
Yellow	Plastic bag	1,2,3,6*	Incineration/deep burial
Red	Disinfected container/ plastic bag	3,6,7*	Autoclave/microwave/chemical treatment
Blue/white	Puncture proof Plastic bag	4,7*	Autoclave/microwave/chemical treatment

*Refer table 1.

2. Quarternary ammonium compounds like cetrimide-cetavolon, savlon.
3. Halogens and their compounds like bleaching powder, sodium hypochlorite and alcohol. Surfaces that have come in contact with blood or body fluids should be cleaned with detergent and clean water. After surfaces have been cleaned, personnel should then disinfect the surfaces by wetting them with a solution of chlorine bleach (sodium hypochlorite) mixed with clean water to reach a concentration of 525 to 600 mg/L of available chlorine (CDC 2003).
4. Formaldehyde gas used for disinfection of rooms.
5. 2% glutaraldehyde is used in the treatment of contaminated instruments.

The various disposal methods include incineration, autoclaving, chemical methods, thermal methods (low and high), ionizing radiation process, deep burial and microwaving. Disposal without treatment is not recommended

for human tissues, sharps and culture from clinical laboratories.

2.5 Incineration

Incineration is usually used for the waste that can not be reused, recycled or disposed of in landfill site. Medical waste incinerators emit toxic air pollutants and toxic ash residues that are the major source of dioxins in environment. [13] Dioxin is one of the toxic chemical, a human carcinogen also, as acknowledged by the International Agency for Research on Cancer. Red bags which contain cadmium, mercury containing items should not be incinerated.

2.5.1 Waste types not to be incinerated are[1]:

Pressurized gas container, reactive chemical wastes, silver salts and photographic or radiographic wastes, plastics such as PVC, sealed ampoules or ampoules containing heavy metals. The Biomedical Waste (management and handling) Rules, 2000 recommend autoclaving for disposables, microbiological wastes and sharps. Operating conditions for autoclave are 121 at 15lb for 60 minutes or 132 at 15lbs for 30 minutes. In a study by Al-khatib et al. suggested that alternatives for waste treatment rather than incineration such as locally made autoclave integrated with a shredder should be evaluated and implemented.[14] Contaminated blood bags are sterilized by autoclaving at 15 lbs for two hours after disinfecting them with 33% formaldehyde and 10% formalin for inactivation of vegetative forms and Bacillus stearothermophilus spores. Thus autoclaving of PVC blood bags is safer than incineration due to poly vinyl chloride content of blood bags. Materials like anatomical and pathological waste, organic solvents, radioactive wastes, lab chemicals and chemotherapy waste are not to be autoclaved.

2.6 Segregation and storage

The types of containers prescribed for waste sharps have to be puncture-proof and can be blue, white or translucent in colour. Syringes and needles must be damaged before they are put in containers, to prevent their re-use /resale. Sharps must always be kept in puncture resistant containers to avoid injuries and infection to those handling them.

2.7 Treatment and final disposal

The rules provide for disinfection and mutilation of sharps by either chemical treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. Treatment by autoclaving/advanced autoclaves/microwaving is also approved. After disinfection and mutilation of sharps they should be disposed in secured landfills as per the rules. As secured landfills are not available everywhere alternate systems recommended include:

2.7.1 Sharps pit: A specialized committee constituted by the Ministry of Environment and Forests to formulate guidelines for implementation of Biomedical Waste (Management and Handling) Rules, 1998, prescribed the details of a sharps pit. Blades and needles waste, after disinfection can be disposed in a circular or rectangular pit lined with brick, masonry or concrete rings. The pit should be covered with a heavy concrete slab, penetrated by a galvanized steel pipe projecting about 1.5 m above the slab, with an internal diameter of up to 20 mm. When the pit is full, it can be sealed completely, after another has been prepared.

2.7.2 Encapsulation: As per WHO (1999), encapsulation is recommended as the easiest method for the safe disposal of sharps. Sharps are collected in puncture-proof and leak proof containers, such as high-density polythene boxes, metallic drums, or barrels. When a container is three-quarter full, a material such as

cement mortar, bituminous sand, plastic foam, or clay is poured in until the container is completely filled. After the medium has dried, the containers are sealed and disposed of in landfill sites.

2.8 Universal precautions to be taken for handling clinical waste

Workers exposed to clinical waste should follow the universal precautions like awareness about different types of infectious diseases, proper personal care by using standard protective barriers and safe handling of clinical waste to prevent health hazards. Protective eye glasses and a face mask must be provided and used where blood, body fluids are likely to splash on to the mucous membranes of the eyes, nose or mouth. Healthcare personnel who are in continuous use with sharp instruments must wear puncture-resistant gloves, gowns and other protective barriers and handle all contaminated wastes carefully to avoid direct contact. Protective barriers reduce risk of exposure to infectious material by no contact with broken skin or mucous membranes. Vaccinations for all employees handling human autopsy waste should include tetanus and diphtheria (Td), hepatitis A, typhoid, hepatitis B, and polio.[12]

3. Legal aspects

Till July 1998, there was no system for proper waste disposal. Most of the hospitals were disposing their waste along with general waste. The Supreme Court directed all hospitals with 50 beds and above to install incinerators or any other effective alternate methods under their administrative control. In 1994, a public interest writ petition filed against dumping of Hospital waste from Safdarjang Hospital in New Delhi.[8] Government took a long time to act on the directions of the Supreme Court in formulating the guidelines for enforcing the standards in hospital waste disposals and the Biomedical Waste (Management and Handling) Rules under sections 6, 8 and 25 of the Environment (Protection) Act, 1986, and was passed in 1998. Section 3 gives a general power to the Government of India to take any measure in protecting the environment, which includes imposing punishment and recovering compensation for the victims of pollution. The Government of India (notification, 1998) specifies that Hospital Waste Management is a part of hospital hygiene and maintenance activities.

Two other amendments have come through since. The first amendment notified on March 6th 2000 is referred to as Biomedical Waste (Management & Handling) (Amendment) Rules 2000. This amendment only changed Schedule VI of the rules, concerning having waste management facilities for treatment of waste. Even when the first deadline for eight cities with a population of more than 3 million was over, these cites had not been able to achieve anything significant in this direction. This amendment thus extended the deadline for implementation for the first phase. The second amendment to the rules was notified on 2nd June 2000. Some of the major changes made included defining the role of the municipal body of the particular area, nominating pollution control boards/committees as prescribed authorities, addition of forms for seeking authorization to operate a facility and for filing an appeal against order passed by the prescribed authority. The entire country now comes under the umbrella of the rules as 31 December 2002 was the deadline for the last phase of implementation of the rules covering all the healthcare institutions, in cities, towns and villages nationally.

However, since the work involved a lot of technical intervention like monitoring the air emission from the incinerators, monitoring of the waste water effluent etc. eventually it was felt that pollution control departments would be appropriate as the prescribed authority and an amendment (Second Amendments to the Rules,

June 2000) was made to this effect. A prior approval from the central pollution control board (CPCB) should be obtained after conforming to the settled standards and also that the CPCB should regularly inspect different hospitals and monitor the garbage disposal processes. Schedule VI provided a schedule for arranging waste treatment facilities like incinerator, autoclave, and microwave systems.

The State Pollution Control Board is declared as prescribed authority for grant of authorization. An authorization shall be granted for a period of three years including an initial trial period of one year from the date of issue. Every occupier/operator of any institution where biomedical waste is generated, and handling shall apply on Form I for authorization to board except those providing treatment/service to less than 1000 patients a month. Form II is used to submit an annual report to the prescribed authority by 31st January every year, to include information about the categories and quantities of biomedical wastes handled during the preceeding year. When any accident occurs at any institution or during transport of such waste, it should be reported in form III to the prescribed authority. As per Motor Vehicles Act, 1988, untreated biomedical waste shall be transported only in such vehicle as may be authorized for the purpose by the competent authority as specified by the government.

For common disposal /incineration sites, the municipal corporation, municipal boards or urban local bodies, as the case may be, shall be responsible for providing suitable common disposal/incineration sites for the biomedical wastes generated in the area under their jurisdiction and in areas outside the jurisdiction of any municipal body, it shall be the responsibility of the occupier generating. For violating the provisions of these rules, the board can file a complaint under section 15 of the Environment Protection Act which provide for imprisonment which may extend up to 5 years with fine. The Board can also have directions for closure of any defaulting hospital/clinic/institution under section 5 of Environment Protection Act as per powers delegated by the Central Government.

4. Conclusion

It is the ethical and social responsibility of healthcare professionals to control the process of disposal of dangerous wastes of healthcare sector. The hospital waste is risk to the patients and personnel who handle these wastes, and also a threat to the public health and environment. Laboratory waste management requires a system approach, and should be made aware of the potential risk of mishandling the waste. Safe and effective management of waste is also a legal necessity. Lack of concern, motivation and awareness are the problems faced in the proper hospital waste management. Proper collection and segregation of biomedical waste are important. The most imperative component of the waste management plans is to develop a system and culture through education, training and persistent motivation of the healthcare staff.

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