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Alternative Waste Management Strategies

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Waste management is an invisible part of the daily activities in a busy operating room. Although most everyone can agree that the control of the various forms of waste and the confusing definitions, regulatory compliances, and local policies are costly, little has been done to conceptualize the magnitude, complexity, and economic impact of the issue (Fig. 1).

A handwritten sign on a waste collector's large collection cart in a large teaching facility reads, "No one knows what I do until I don't do it." He may well have a key to the solution. If, in fact, he "stopped doing it" and a study was conducted on the waste being generated, beginning with the outside supply vendor all the way to the final disposal location, the results would serve to illustrate graphically the magnitude of the issue. The analysis of the issue does not start with the waste collector; it begins at the point of product purchase [1]. Waste minimization starts with reducing or eliminating it at the source. The most effective solutions can be found by analyzing the multiple non-value-added processes, steps, and wasted personnel efforts that are significantly contributing to the problem throughout the facility. Begin with a careful analysis of surgically related products that enter the facility and then an inventory of all the purchased items that leave as a form of waste. Analyze the numbers of personnel required to order, manage an order, load materials, transfer and unload, stock in a warehouse, break down to the unit of issue, and discard cardboard containers. Calculate the number of times and the number of personnel required to transport these items to the point of use and the

volumes of waste in the form of wrappers and containers collected.

Over the past 3½ decades, changes in surgical health care delivery have radically altered the types of instrumentation and surgical products that are routinely used. We moved from an exclusively nondisposable environment to one that is predominantly disposable, with the exception of the durable surgical instrument sets. In the continuing and growing efforts for minimally invasive procedures, industry leads the way in the production of disposable products that provide the portals through which these procedures are accomplished. Along with disposable surgical instrumentation, the full range of sterile surgical attire and draping materials has evolved. With this has been a full shift in the generation, types, and disposition of the waste generated by surgical procedures [1].

Categorically, these include the following:

- Surgical patient drapes
- Surgical table, ring stand, and Mayo drapes
- Surgical gowns
- Sterile team gloves
- Sterile durable instrument sets
- Sterile basins
- Disposable items (eg, blades, suture) and instruments (eg, trocars, miscellaneous portals and graspers, scissors)
- All types of surgical sponges and packing
- Nonsterile bed linen, blankets, pillowcases, positioning aids, and pressure prevention aids
- Suction bottles containing the waste from anesthesia-generated secretions and surgical wound residue and irrigation

In 1967, none of the items listed were disposable. Every item in the operating room was sent to the hospital laundry or to the sterile processing

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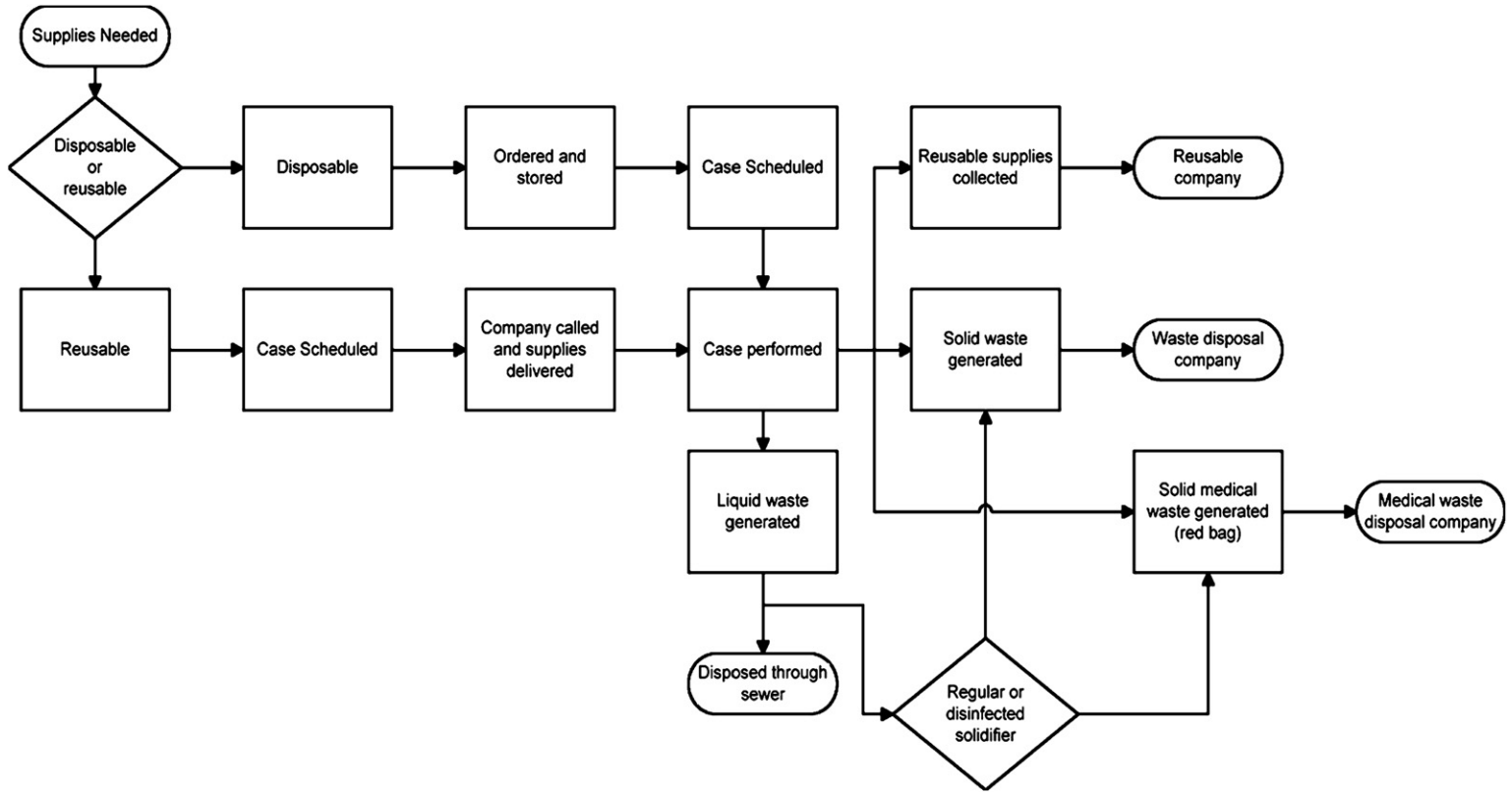


Fig. 1. Surgical waste stream.

department. The amount of material sent out as waste was minimal. In 2007, virtually everything, with the exception of durable instruments, is discarded as waste in some form. Between 2 and 4 million tons of hospital waste are generated and discarded annually from health care facilities alone [2]. Clearly, there have been advances in technology and surgical practices. New threats have been introduced that were not known or present in the days of complete nondisposable equipment, including HIV, hepatitis B, hepatitis C, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), Creutzfeldt-Jacob disease (CJD), *Acinetobacter*, severe acute respiratory syndrome (SARS), and other viruses that threaten to inflict disease on health care personnel and patients [3]. Reactions to these new threats appeared in the form of universal precaution standards and the Medical Waste Tracking Act (1988) [4]. By this time, disposable use was the norm and the natural tendency was to treat everything as infectious waste and send it to the incinerator. Economic and environmental variables soon joined the equation. The requirement to do it faster, better, less costly, and environmentally safe became the expectation.

The operating room is typically considered a cost-generating area. The fact that it is also one of the largest and most costly waste-generating areas is overlooked in most institutions. That waste, from a cost and published review perspective, should be less than 15% regulated medical waste (RMW) or “red bag waste.” The remainder of the waste generated in the operating room in the form of solid waste or regular trash should comprise the remainder. From a typical cost perspective, red bag waste costs a facility 10 to 25 times the cost of solid waste [5]. The amount of waste generated daily in every business and organization in the United States is staggering compared with European nations. We have disposable containers, boxes, and paper and plastic bags for everything imaginable. A food court in a typical shopping mall requires one or more full-time personnel to manage waste containers. Health care facilities are no exception, with the added problem of the confusion as to what might be potentially infectious. Up to 85% of waste that should be disposed as solid waste is instead placed in infectious waste containers [5,6].

Waste cost estimates

The economics for disposition of hospital-generated waste is driven by multiple variables,

including the weight and volume; the locale; crossing state lines; and regulatory interpretations by local, state, and federal mandates. The following are the current ranges available from published reports and unstructured surveys:

- \$0.02 to \$0.06 per pound for solid waste
- \$0.30 to \$1.25 per pound for biohazardous/infectious waste (red bag)
- \$1.00 to \$6.00 per pound for hazardous waste

Medical waste defined

In the course of treating patients, hospital personnel generate a remarkable amount of waste. By classification, multiple categories of wastes are created, including RMW, also referred to as infectious waste; hazardous chemical waste; and recyclable, reusable, and solid waste. Within these categories are further classifications, including liquids and sharp items (Fig. 2).

There is not a universally accepted definition for RMW; however, the definitions offered by regulatory agencies are similar. The Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), and the Occupational Safety and Health Administration (OSHA) agree that “regulated medical waste includes those wastes with the potential for causing infection and for which special precautions are prudent” [7].

The CDC’s guidance for Universal Precautions suggests that blood and body fluid precautions be used for all patients regardless of their infection status. These precautions stem mainly from the need to minimize exposure to the viruses and microbial organisms responsible for causing disease. “In effect, all free flowing blood, blood products, body fluids containing visible blood, and other specific body fluids such as cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, pericardial fluid, amniotic fluid, vaginal secretions, and semen should be handled with universal precautions and managed as regulated medical waste” [7–9]. All 50 states have specific regulations that address medical waste. These regulations are extremely diverse and vary from simple definitions to stringent treatment, storage, and disposal requirements [7]. Several states stipulate that sharps must be rendered unrecognizable (defined as less than 0.5 inch in length) before final disposal.

The EPA defines infectious waste in the *Guide for Infectious Waste Management (EPA530-SW-86-014)* as waste that “contains pathogens with

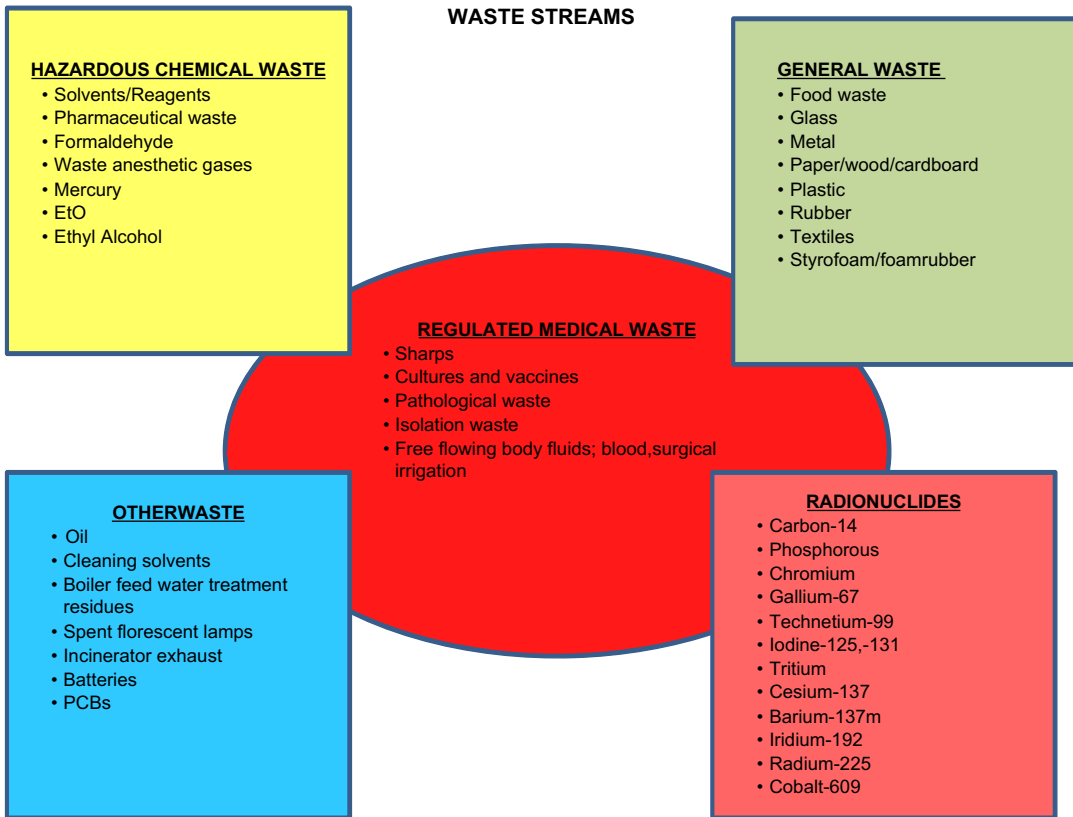


Fig. 2. US Army Center for Health and Promotion and Preventive Medicine. A commander's guide to regulated medical waste management at army medical treatment facilities. Available at: <http://chppm-www.apgea.army.mil/documents/TG/TECHGUID/TG177.pdf>. (Adapted from US Army Center for Health and Promotion and Preventive Medicine. A commander's guide to regulated medical waste management at Army medical treatment facilities. TG 177. Aberdeen Proving Ground, MD: US Army; 2001. Available at: <http://chppm-www.apgea.army.mil/documents/TG/TECHGUID/TG177.pdf>.)

sufficient virulence and quantity so that exposure to the waste by a susceptible host could result in an infectious disease" [8]. Included in this reference as RMW are blood-soaked bandages, discarded surgical gloves, discarded surgical instruments, needles, removed body organs, and discarded lancets [8]. Most medical wastes do not meet these criteria.

A common confusion point is the requirement and interpretation by states that waste is considered RMW if it contains free-flowing blood or fluids or materials like sponges and lap packs saturated with blood, bloody fluid, or caked blood. This OSHA rule defines RMW but does not regulate medical waste disposal. This definition has been used by many states and facilities to determine waste classification policies. Many facilities prefer to err on the side of caution, partly in fear of a large fine or incident involving real or perceived risk to waste management personnel [10,11].

Appropriate disposal policies for all waste streams need to address worker safety, public health, and environmental considerations in addition to regulatory compliance. After several decades of disposable use, there is a need for a dramatic cultural shift to consider disposal technologies and services as part of a renewed waste management concept. This system requires a change in thinking about upstream waste management, including the elimination or minimization of some of the wastes and reuse and recycling of others [10]. By definition, infectious waste is that fraction of medical waste that has the real potential to transmit an infectious disease. According to most authorities, infectious waste should not exceed 15% of the total hospital waste stream [12]. Recent published studies indicate that essentially everything generated in the operating room as waste leaves the facility as RMW rather than being carefully screened and separated [6].

The prevention of disease transmission to patients or to health care personnel is the primary intent of infectious waste management. The emphasis requires starts on the management of the process rather than technologic fixes supplied by industry. Many times, this has proved to be an expensive diversion rather than an effective solution [12].

Goals for the management of all health care facility-generated waste should include the following:

- Reduce or eliminate it.
- Contain costs associated with waste.
- Understand the true categories and definitions of waste.
- Appreciate waste as a “non-value-added” component of the surgical process so that it can be systematically analyzed and functionally approached.
- Establish an environment in the perioperative setting that is safe from physical and health hazards for staff and patients.
- Reduce all risks for occupational illnesses and injuries.
- Consideration of the long-term effects of surgically generated waste, beginning with the acquisition of the surgical supplies through the ultimate disposition of all waste, on the environment, people, equipment, and property.
- Remain fully compliant with all regulations imposed by federal, state, and local laws. It is important to note that the requirements of some states for the management of RMW exceed those of other states.
- Maintain constant vigilance and an education process covering the range of personnel from the purchasing agent to the landfill contractor regarding the risks associated with hazardous and infectious waste.
- Establish flawless administrative and engineering controls to create, sustain, and maintain safe work practices [13].

A frequently cited study using the collected waste from 27 surgical procedures consisting of spinal, cardiovascular, orthopedic, and general surgery generating 610.5 lb (274.4 kg) illustrates the issues. The contents by weight consisted of disposable linen (39%), paper (7%), plastic (23%), and miscellaneous (27%). The contents by volume consisted of disposable linen and plastic (69%), plastic basins (23%), and miscellaneous (7%). The researchers intentionally did not include the weight or the contents of body fluids containers in suction canisters. Linen, paper, and

recyclable paper accounted for 73% by weight and 93% by volume. The study concluded that a 73% reduction in weight and 93% by volume could be realized if reusable products were substituted for the items disposed [14].

A similar recently published report illustrates a continued practice of expensive waste management. In this study, 92% of the weight of red bag waste was discarded inappropriately as biohazardous waste [15]. These reports signal the need to examine current practices critically with respect to all waste generated in the perioperative environment from the multiple perspectives of cost and personnel resource requirements from purchasing through final disposition, recycle, or reuse procedures.

Cost estimates are as follows:

\$0.02 to \$0.06 for normal waste
 \$0.19 to \$0.40 for biohazardous waste
 \$1.00 to \$6.00 for hazardous waste

Medical wastes as facility space issues

Waste management has an impact on facility space requirements. There is a necessity for locations to separate the various types of waste at the site of origin and another requisite for staging disposal locations, such as a loading dock or a logistic warehouse space. There must be appropriate areas to wash and clean utility vehicles that transport soiled materials within the facility and locations to store clean and soiled utility vehicles. There needs to be ample space for soiled and clean utility rooms that are readily accessible by transportation personnel away from the public thoroughfares and public elevators if possible.

The systems selected for management of waste need to be compatible with and included in design and construction projects during the planning phases of a project rather than as an afterthought. Waste is not glamorous and is seldom considered, but the cost and safety factors are staggering. The flow of materials into and the waste flow that leaves the entire perioperative area need to be planned into the physical layout in any renovation or new construction project. Failure to consider the traffic flow patterns and locations for these items results in built-in inefficiencies. The full cradle-to-grave process must be considered for everything that enters the perioperative environment and requires some form of final disposition. This includes waste anesthetic gasses (WAG), smoke plume, specimens, sharps, instruments,

loaner sets, disposable and nondisposable sterile items, recyclable paper, plastic items, liquid waste, and linens.

Reconsideration of nondisposable solutions

Shaner and McRae [12] propose that “facilities should firmly support the judicious reuse of materials and should explore opportunities where the use of reprocessed materials is feasible and available.” This effort within hospitals should provide quality products and thwart efforts to increase reliance on disposables. Disposables are costly, increase waste generation, and have not demonstrated definitive decreases in infection rates in the perioperative arena.

Liquid waste

Liquid regulated medical waste disposal options

Liquid waste generated during surgical procedures can be disposed using one of four methods (Fig. 3):

- Close the system, secure the top and ports on the canister (container), and place the contents in a red bag as infectious waste. This is the least favorable option. The contents are subject to leaking if the lids or ports dislodge, potentially exposing waste management workers as the liquid waste is transferred and transported to the final destination. The

liquid contents in a 3-L canister weigh 7.5 lb. Estimates per pound vary by state and location. Costs range from \$0.60 to greater than \$1.00 per canister.

- Transport the filled canisters to a soiled utility area, and pour the contents in a hopper utility sink into the normal waste water system. No formal research data are published indicating the prevalence of this practice; however, industry estimates are that from 30% to greater than 65% of facilities discard liquid surgical waste in this manner. This is the most economic practice for health care facilities and the one with the highest potential risks to staff and patients. Full personal protective equipment (PPE) is required while pouring the contents of liquid surgical waste. Normal practice suggests that gowns and gloves be removed before leaving the operating room by scrubbed personnel. This would require donning a new gown, gloves, and mask if the operating room staff is responsible for discarding waste at the completion of a procedure. This sets up discretionary PPE use negating safety, engineering controls, and compliance during operating room turnover.

A 2006 survey of 340 members of the Association of Occupational Health Professionals (AOHP) in health care revealed the three most significant concerns for health care workers to be safe patient handling, blood-borne pathogen exposure,

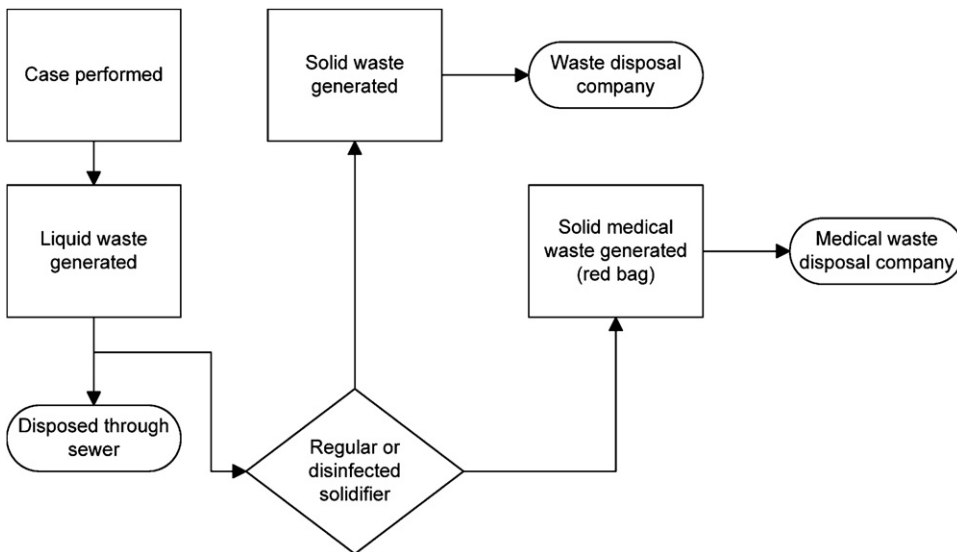


Fig. 3. Surgical liquid waste disposal options.

and respiratory protection. A total of 73.5% of those surveyed were specifically concerned about the exposure to blood and liquid waste [16].

- The next alternative method involves adding a solidifying agent to the container to create a solid gelatinous mass. This eliminates the potential for fluid leakage but does not reduce the weight of the canister as RMW. A supplemental practice is the addition of sanitizing agents, including chlorine or glutaraldehyde. In some locations, states tolerate this as “treated” medical waste and allow the canister and contents to be disposed as solid waste (white bag). There are limited data supporting the safety and efficacy of this practice.
- Recently introduced are closed disposal systems. These are self-contained units that collect fluid waste at the surgical field and allow for disposition directly into the waste water system using hands-free and no-exposure methods.

The primary advantages of these systems include the following:

- Minimize risk to staff by minimizing the number of times and the number of personnel required to handle the liquid waste.
- Reduce RMW and RMW transportation.
- Eliminate bulk weight and volume leaving the facility.

It should be noted that all states, with the exception of the District of Columbia, allow this practice.

No matter how you view it, RMW is expensive. Priorities should be protection of staff and patients, costs associated with practices, and environmental concerns [17].

Workers who handle waste tend to be the lowest paid and the least educated members in the health care setting. These personnel often become unseen and not considered with respect to proper instruction in the proper handling of various wastes generated in a facility. Severe fines occur when personnel are exposed to harmful wastes or wastes are disposed improperly by regulating agencies (Tables 1 and 2) [12].

Human blood and blood products

Because it is impractical to test all blood for the presence of every possible pathogen, it is prudent to manage all blood and blood products as infectious waste. It is logical to extend this practice to the wastes associated with blood specimens and to handle them as though they

Table 1
Fluid medical waste solidifiers

Company	Product
Colby manufacturing corporations	ViraSorb ^a
DeRoyal Industries ^a	DeRoyal Solidifier
DiSorb Systems, Inc. ^b	SafeSorb
Metrex, Inc. ^c	PremCide
	Canister Express
	The Solidifier
Microtek Medical, Inc. ^d	LTS Plus
	Isosorb
Safetec of America, Inc. ^e	Red-Z
	Green-Z
	Yellow-Z
Zapatec LLC ^f	Zaploc

^a Powell, Tennessee.

^b Philadelphia, Pennsylvania.

^c Orange, California.

^d Columbus, Missouri.

^e Greensboro NC Inc., Buffalo, New York.

^f McLeansville, North Carolina.

were contaminated. Two recommended treatment methods are steam sterilization and incineration. In addition, blood and blood products may be discharged directly to a sanitary sewer for treatment in the municipal sewerage treatment system provided that secondary treatment is available [18].

Table 2
Surgical fluid waste collection and disposal systems

Company	Product
Bemis ^a	Vac-U-Port
	Vac-U-Station
	Quick Drain
Cardinal ^b	Medi-Vac
	SAF-T-Pump
DeRoyal Industries ^c	Aqua-Box
Dornach Medical Systems ^d	Transposal
Merit Medical Systems, Inc. ^e	Merit Disposal
MD Technologies ^f	Environ-mate DM 6000 Series
	Suction Drain System
Stryker Medical ^g	Neptune

^a Sheboygan, Wisconsin.

^b Dublin, Ohio.

^c Powell, Tennessee.

^d St. Louis, Missouri.

^e South Jordan, Utah.

^f Galena, Illinois.

^g Kalamazoo, Michigan.

Surgical linen and drapes

Waste generation is directly related to purchasing and supply practices and habits. A generation of perioperative nurses has only known the use of nonreprocessable, single-use, sterile surgical products. Many of today's seasoned operating room supervisors can remember nondisposable gowns, table covers, and draping material, with the associated labor of light tables, folding rooms, and iron-on patches [12,15]. Many debates and discussions were conducted in Association of periOperative Registered Nurses (AORN) forums with respect to the number of allowable patches per item, thread counts in cotton muslin products, and other issues related to suitability for use in surgical settings. Light tables, folding tables, and lint became history with the introduction of disposable packs. Manufacturers soon learned the art of marketing custom packs with every conceivable item being "built" into a single bundle, with the promise of cost savings in time, effort, and efficiency. The savings that were to be realized from fewer Central Sterile personnel quickly evaporated with the new requirement for waste management personnel and additional expensive locations to hold waste awaiting removal.

In the early 1990s, new nondisposable surgical gowns were introduced to the market; however, without staff, hospitals were no longer equipped or staffed to launder, inspect, fold, and sterilize surgical drapes and gowns. Most operating room supervisors, cognizant of muslin gowns and drapes, were not the least bit interested in revisiting those issues. The introduction of the disposable custom packs was a more than satisfactory solution. For a time AMSCO Sterilizer Company (STERIS, Mentor, Ohio) initiated plants throughout the country to provide nondisposable solutions in the way of sterile reprocessed drapes, gowns, and table and Mayo stand covers without winning the hearts and minds of those remembering the not so "good old days" of muslin. Ultimately, the AMSCO Sterilizer Company product and services were acquired by Sterile Recovery, Inc. (SRI, Elkridge, Maryland). SRI has the largest US Food and Drug Administration (FDA)-approved reprocessing centers in the United States. The American Hospital Association reports 5747 registered hospitals in the United States [19]. SRI reports having 275 hospitals that use sterile nondisposable packs consisting of gowns, towels, back table covers, Mayo stand

covers, and drapes. The company also reports 371 hospitals that use sterile nondisposable basin sets. Individual items currently being supplied in disposable custom packs, such as surgical sponges, Ascepto syringes, and suction tubing, are supplied by SRI with the nondisposable gown and drape pack. The disposable products are custom selected by individual customers and sterilized as a single unit, eliminating the need to open each item. Changes to the content of these disposable items can be easily altered without having to exhaust a 6-month supply of custom surgical drape packs currently provided by other vendors. Hospitals that use reprocessable surgical gowns and drapes, for example, do so under a service rather than a purchase contract. The service includes the supply of the sterile product from an FDA-regulated facility; the retrieval of the used product; and the return transport, laundering, inspecting, folding, and sterilizing of the items for reuse. This service is becoming available as an addition to primary vendor contracts for those facilities wishing to change to nondisposable use items but not wanting to lose the benefit of existing economic purchasing agreements.

A study published in 2001 in Denmark concluded an overall equal rating with respect to comfort and barrier protection between disposable and reusable surgical gowns. Both products have an environmental impact as waste or water consumption; however, in this study and location, with the reusable products tested in best and worst scenarios, the reprocessable products were slightly superior [20].

Two studies, one conducted in Germany and the other in the United States, concluded that there are no conclusive arguments to support a clinical superiority between disposable gowns and drapes and the reuse components. Both studies clearly establish that disposables generate a considerable amount of clinical waste [21].

Comparative studies conducted in the United States by manufacturers of disposable surgical supplies are inconclusive with respect to the superiority of disposable or nondisposable products. Dated studies comparing reuse and disposable products have limited relevance because of poor study design and the introduction of product improvements and efficiencies in water and power conservation strategies [9]. The use of reprocessable drapes, gowns, table coverings, and basins can reduce the weight and volume of surgical waste by greater than 75% [14].

Research opportunities

There are no significant qualitative or quantitative research methodologies or designs currently available to define all the issues associated with biohazardous waste materials. The few studies available are biased by vendors toward the sale of disposable custom products or reuse products. Approaches like those demonstrated by the Lean and six Sigma strategies [22] provide tools by which the relative value, or nonvalue, in processes can be analyzed and suitable measurement strategies can be applied. Appropriately designed research using validated methodologic approaches can lead to data on which sound decisions contrasting alternative solutions in the disposable, reuse, and recycle matrix for liquid waste; gowns, drapes, and table coverings; basin ware; and appropriate terminal disposition processes can be selected.

Research needs to focus on product space requirements, purchasing practices, costs for use and disposition, inventory, storage, multiple transfer activities between locations, impact on the room turnover process, impact on personnel requirements, and safety. The application of appropriate study designs and methodologies should focus on a 20/20 vision for the future and make sound economic decisions for the protection of staff, patients, and environment and financial resources.

Health care professionals should engage independent experts in study design, methodologic rigor, and appropriate statistical tools to create and validate publishable and replicable evidence to support sound clinical decisions. These studies should contrast alternative products on the basis of the following:

- Life cycle costs, which involves the process of obtaining, transferring, using, and disposing of the product
- Personnel requirements associated with these processes
- Personnel satisfaction with the products and process
- Personnel safety and compliance with EPA environmental controls
- Facility liability costs for noncompliance along the product life cycle continuum

Summary

The health care industry and, more specifically, the perioperative setting have a 30-year history of acquiring a complete disposable habit. The

relatively inexpensive costs of incineration of all waste provided an economic incentive for facilities to downsize personnel required to manage durable goods. That philosophy was sustainable and encouraged by the manufacturers of disposable sterile products. This past decade of these practices has resulted in dioxin and mercury emissions into the environment that are unacceptable. Incinerators are closing or being fined heavily for safety violations. Alternative and more expensive methods of waste disposal, specifically infectious and hazardous waste disposal, are driving cost upward at a rapid rate.

The fast-paced nature of perioperative nursing allows little time to contemplate the costs or impact of these practices; however, nurses are increasingly aware and concerned for their own safety and the safety of those who may be exposed to potential disease-causing materials. It seems to be the time to reconsider the benefits and liabilities of our practice habits. In many instances, handling infectious materials less or not at all may have tremendous advantages that outweigh the simple economics involved. There may be a better balance in our practice. If a concept seems promising, it should be pursued with real research. In the absence of definitive, conclusive, and compelling unbiased scientific evidence, we are directed by industry rather than by our own profession.

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