# Basic Bioengineering: Essential Equipment Use and Troubleshooting

# 10

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## Introduction

Assuring the availability of safe and functioning medical equipment in the developing world is challenging. Given the limited resources, repairing defective medical equipment on the field is an even greater challenge. This chapter discusses the various causes of equipment failure, how to correct those failures, and how to prevent future equipment failures. Learning how to quickly and properly troubleshoot a problem or failure will not only improve patient safety but will reduce equipment downtime and save valuable resources. Regardless of your technical abilities, this chapter will assist you in solving a variety of medical equipment problems.

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## Causes of Failure

**The Essentials**

- *A large variety of available devices result in operating and service difficulties.*
- *Inappropriate donations result in poor quality and nonfunctioning devices.*
- *A shortage of biomed techs or service staff results in nonfunctioning devices.*
- *Inadequate equipment usage training for clinical staff results in failures.*

Equipment problems and failures occur at a much higher rate in the LMIC (lower- and middle-income countries) than in US health systems. There are many factors contributing to this unfortunate situation, and they include the wide variety of available equipment, the source and condition of this equipment, and the shortage of biomedical technicians or qualified maintenance personnel to maintain it.

A surgeon in the USA will typically be exposed to a limited variety of equipment because the equipment is usually selected based upon the desires of the surgeon and medical facility where they practice. Unfortunately, when traveling globally, surgeons will be exposed to a significantly larger variety of medical devices. According to the World Health Organization (WHO), ". . . there are more than 10,000 types of medical devices available. The selection of appropriate medical equipment always depends on local, regional or national requirements; factors to consider include the type of health facility where the devices are to be used, the health work force available and the burden of disease experienced in the specific catchment area. It is therefore impossible to make a list of core medical equipment which would be exhaustive and/or universally applicable" [1]. This exposure to such a vast number of devices results in a challenge not only with servicing and maintenance but also with proper operation of the equipment.

Although many hospitals, clinics, and surgical teams try to stretch their budgets by relying on donated equipment, the need or desire to depend upon "free" or donated equipment can often have tragic consequences. Many users are more concerned with what they can get for the lowest cost, rather than the quality or condition of what they get. "Many developing countries are increasingly dependent on donor assistance to meet the equipment needs of their health care systems. However, because not all important parameters are taken into consideration, donations sometimes do not achieve their intended objectives, and could even constitute an added burden to the recipient health care system" [2]. Furthermore, the equipment providers may come from a variety of different countries. This results in exposure to a larger number of manufacturers and models, equipment requiring different power sources, lack of or different language operator, and service manuals. Medical facilities in the LMIC are littered with inappropriate medical devices that will never


**Fig. 10.1** The majority world is littered with inappropriate medical devices that will never function in the environment to which they were sent

function in the environment to which they were sent (Fig. 10.1). "Few documented case histories are available to tell us what actually happens to used health care equipment that arrives in developing nations. However, the sense among some biomedical engineers and health care professionals who have extensive work experience in these countries is that less than 30%, perhaps as low as 10%, of used equipment ultimately becomes operational" [3]. This is the sad reality facing many visiting surgeons when they reach the place of service. Encountering inappropriate medical technology (equipment), a lack of medical devices, and broken equipment should be expected.

Procuring appropriate medical technology, training the staff on proper setup and usage, and having a maintenance support system remain a low priority and commitment for most organizations and LMIC healthcare facilities. "Economic changes and financial problems, and a growing burden of disease have contributed to an increasing dependence on donor assistance in the area of health care for many developing economies. This assistance usually includes physical equipment and spare parts, and in some countries, nearly 80 percent of health care equipment is funded by international donors or foreign governments. The introduction, utilization and maintenance of health care equipment require substantial financial, organizational and human resources. Often, this is either not recognized, or not enough attention is paid to it. In the Sub-Saharan Africa region, for example, a large proportion (up to 70 per cent) of equipment lies idle due to mismanagement of the technology acquisition process, lack of user-training and lack of effective technical support" [4].

Even without these realities, normal wear and tear on medical equipment is going to result in a need for regular service. The lack of biomedical technicians or any other technical support often leaves the clinical staff and surgeons responsible for repairing the equipment they are using. They are too often untrained and not up to the task. Anticipating these problems and being prepared to address them will help the surgeon respond quicker and more effectively to the needs.

## Pre-trip Planning

Do not assume that the healthcare facility which you are going to will have all the required equipment, accessories, and supplies that you will need. Determine what equipment you will need, and contact the facility to verify what is already there and if the condition of the equipment is functional. Also, ensure that they have the required accessories and any spare accessories and/or supplies. Obtaining an accurate answer will be a challenge because most healthcare facilities in the LMIC do NOT maintain an active equipment inventory. Knowing what accessories are available and the condition of the equipment and accessories is an even greater challenge. If there is any doubt, arrange to have the needed equipment and accessories provided and/or plan to take some with you when you go.

## Correcting the Failure

Despite your best efforts, your equipment has failed. Now what? Just as patient history is vitally important in diagnosing the medical problem, asking the correct questions and gathering historical information on the equipment and events leading up to the failure will better assist you with determining what exactly is wrong and how to correct it. Avoid making quick assumptions and carefully think through proper troubleshooting steps.

> When it comes to troubleshooting medical equipment failures, there is a tendency to jump to wrong assumptions and miss what might otherwise be the real problem. This is especially true in some limited resource settings where parts are not readily available and biomed training or troubleshooting skills have not been taught. Before jumping to conclusions and tearing into a medical device that does not appear to be working correctly, it is best to begin with the most obvious and likely problem areas. Taking a medical device apart should be the LAST step in troubleshooting the problem. [5]

Equipment problems and/or failures will almost always fall under one of the following four areas: **p**ower, **p**rocedure, **p**atient accessories, and **p**arts. Worldwide

**Table 10.1** The four P's of troubleshooting

| | |
|---|---|
| Power | The problem is related to some form of power issue. Loss, incorrect, etc. |
| Procedure | The problem is related to an operator error or incorrect procedure |
| Patient | The problem is related to a patient accessory or interface device |
| Parts | The problem is related to a failed internal part/component |

Biomedical Charitable Services (WBCS) refers to these as "Rick's four P's of troubleshooting" (Table 10.1). Troubleshooting will become much easier to remember and perform if you use the four P's in your approach.

As a clinician, you know that a proper diagnosis of the patient not only includes the patient history but often access to the proper diagnostic tools and equipment as well. Likewise, when you are troubleshooting the medical equipment, you will need some basic tools and test equipment. It should be possible to carry a few small items if you are going to an environment that does not have those on site. The minimum tools would include regular and Philips screw drivers and needle nose pliers. The minimum test equipment should include a small multimeter that will read AC and DC voltage and impedance (resistance). Obviously, the greater assortment of tools, test equipment, spare parts, and disposable accessories you take, the better off you will be.

You've heard the saying "you are only as good as your tools" or "the right tool for the right job!" Successful troubleshooting and repair will require these. Finding these items when you reach your place of service will be difficult. Identify suggested tools and a multimeter that can be purchased locally before you leave (Figs. 10.2 and 10.3).

Push button quick release ratchets
1-3/8-in female x 1/4-in male socket adaptor and 1/4-in drive spinner handle
1/4-in drive bit adaptor and 13-1-in insert bits- Ph, slotted, torx & 4-hex
6-in long nose pliers and 6-in adjustable wrench
Wire brush and 3-hose clamps, size: 1/2-in, 1-in, 2-in
1-3/4-in x 30-ft PVC tape and 1-retractable utility knife
1-tire gauge and a 6 1/2-in heavy duty mini flashlight with 2 batteries

**Fig. 10.2** Small basic tool kits come in handy while serving internationally


**Fig. 10.3** Low cost meters can be found in stores

## Power Problems

Always begin the troubleshooting process by checking all aspects of the power. Inspect power cords for connection, both at the power outlet and at the back of the device. Insure that the plugs are firmly seated at both ends. Also check the actual condition of the cords and plugs – if they appear worn, cut, or kinked near the ends, replace them. Power plugs from the UK that have three flat blades often contain fuses inside the power plug. These internal fuses occasionally blow and must be checked with a meter or the power cord substituted to verify it is good.

Verify the actual power condition and availability (voltage, frequency, stability, etc.). Is there even power at the outlet and is it at the proper voltage? Poor power sources may be poorly regulated, running too high or low, and can damage the equipment. Also verify that the power requirement of the device matches the power it is being plugged in to (the destruction of a 110 V piece of equipment is usually instantaneous if it is plugged into a 220 V system). It is common to find incorrect power plugs forced into outlets or inappropriate adaptors being used. This occasionally results in cords being plugged into the wrong voltage outlets (Figs. 10.4 and 10.5).

If the power outlet and power cord have been verified to be good and the device is still not coming on, check for blown fuses. Some fuses are easy to find and remove for inspection. Some will require a small screw driver to remove from the plug or fuse holder and others may be located inside the device and require the cover to be removed. Some glass fuses can be visually inspected and it is obvious when they are blown. Others, however, may not be visible or may even appear to be good, but are not. It is always best to verify with an ohm meter if one is available or simply replace the fuse.

**Fig. 10.4** Power outlets will vary not only in styles but in voltage and frequency. Always make sure the device is plugged in to the correct power source

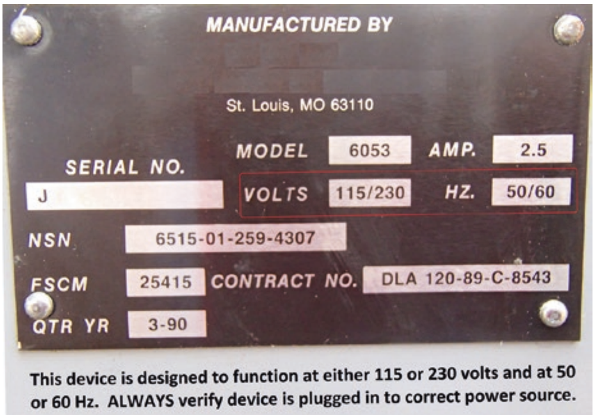


**Fig. 10.5** Always check the equipment nameplate to verify the input power requirement

If a blown fuse is found and replaced and the device blows the fuse again, this is an indication there is a defective component inside the device. The device should be taken out of service and given to a qualified technician to inspect and repair. It is not uncommon to find insect or rodent nests and damage internally. Urine has been known to corrode contacts, components, and wiring, which can burn out power supplies or circuit boards. Chewed wires are also common. This type of damage is typically not repairable without further technical assistance and parts.

If the device is battery operated, check the condition of the batteries and ensure that they are properly installed. Batteries installed backward (or upside down) are a common problem and cause the device to not work. Rusted and/or corroded battery contacts inside the device will also result in failure, even when new batteries are installed. Do not make assumptions with batteries, but verify condition and proper installation. Replacement, if you are uncertain, may be the best way to check.

Keep all air filters clean, fans unblocked, and items off and away from the equipment to prevent overheating of the power supply. Proper air ventilation on some devices is critical.

## Procedure Errors

User or operator errors are something no one likes to admit, but it happens especially when trying to use a piece of unfamiliar equipment. Because it is a difficult subject to address and safety has been compromised when users do not want to admit or attempt to cover up errors, the US health systems now refer to them as "procedure errors." The important thing is not to lay blame, but to correct the error and to prevent future errors. In the limited-resource environment where there may be limited numbers or no equipment user manuals available or where they are in a different and unfamiliar language, operator or procedure errors are more likely to occur. This problem is also exaggerated when the clinical users have not received proper training on the usage of the device.

It is vitally important, therefore, that questions are asked and procedures checked to verify the problem is not simply a problem of improper usage. Do not assume that the user is infallible. If you or the other clinical users don't know how the equipment functions, ask or find out how to operate the equipment correctly. If you are working in an environment with Internet access of sufficient quality, many times the user manual can be downloaded from the manufacturer or other technical websites.

Lack of proper handling of the equipment is also considered a procedure problem and referred to as equipment abuse in the US health systems. Equipment abuse results in more failures than most people realize and should be addressed when encountered. Additional details on abuse are covered under the patient accessories troubleshooting step.

## Patient Accessories/Interface Failures

Damage from lack of care or abuse of the equipment often results in broken accessories or parts. Patient accessories or interface devices such as patient cables, blood pressure hoses, and pulse ox sensors are the weakest link in medical equipment. These parts receive the most stress, wear and tear, and will eventually all wear out and fail, even if the users give exemplary care. However, not handling these devices carefully will shorten their life expectancy.

Unless you have basic test equipment such as a multimeter and/or a patient simulator, verifying that the problem is in the patient accessories can be difficult. Your primary method of troubleshooting may be limited to visual examination and swapping out accessories. Closely examine cables, wires, hoses, sensors, or other small parts for kinks or worn areas. In limited-resource settings where single-use items are frequently used multiple times, worn-out accessories is a common problem. It is often obvious where the problems are located. Worn-out single-use sensors, electrosurgical pencils and patient return pads, and even electrocardiogram electrodes are frequently used beyond their ability to conduct signals. When in doubt, replace them.

Finding spare or replacement accessories is a frequent problem. Unfortunately, it is common to discover that the healthcare facility does not have or does not know where any spare accessories are located. You may be faced with equipment being placed out of service while waiting for new patient accessories to arrive. Therefore, as mentioned earlier, it is a good practice to arrange for or take spare accessories with you when you travel.

The lack of troubleshooting and repair skills is a frequent problem in the limited-resource environment, but it can be a politically and culturally sensitive area to address. National maintenance personnel often struggle with a lack of tools, test equipment, spare parts, and other proper repair resources. Moreover, a lack of troubleshooting training and experience often results in ineffective service attempts in most limited-resource environments. This is often manifested by the quick and haphazard repairs that use a variety of different tapes or materials to patch together broken wires and accessories. When patient accessories are found taped together, it is usually a safe assumption that the connections are insufficient. Replace these accessories as soon as possible.

To reiterate the previous quote, "Taking a medical device apart should be the LAST step in troubleshooting the problem" [5]. It is critical that these common causes and failures mentioned above be checked prior to opening the equipment and checking for internal part failures.

## Parts Failure

Although most people assume the contrary, internal component failures are actually the least likely problem. Carefully check the other three "P's" of troubleshooting before determining the problem is a failed part inside the device. If it has been determined that the device has a failed internal part, consider the possible appropriate service options before disassembling the equipment. These options include repairing the device on site, waiting for a qualified service tech to come for a repair, and sending or taking the equipment to a location where it can be properly serviced. Disassembling the equipment by an inexperienced person who does not have diagnostic equipment and spare parts available is more likely than not to result in a non-fixable mess.

Equipment is often not repairable on-site without proper replacement parts. However, if qualified service personal are available and parts are available, then it is appropriate to have them check for and replace any missing or defective parts.

Unless the clinical staff member has electrical and/or mechanical aptitude, choose one of the following options:

- Leave a detailed note describing the problem or failure with the equipment so the qualified service people will know why it was taken out of service.
- If the service personnel are available, meet with them to discuss the problem. Service on equipment is most successful when the users discuss the details of the problem with the service techs.
- The last and often most appropriate option is to send the equipment out for repair or wait for qualified help to arrive. If you do not have the proper tools and test equipment (basic meter and/or simulator) to troubleshoot the device, you should not open it and make a bad problem worse. Asking another unqualified hospital staff person to service the equipment is equally dangerous or ineffective. A qualified service person will know their limitations (abilities AND resources) and will seek outside assistance if needed. Disassembling and fiddling with defective equipment when there are no parts to repair it only results in further damaging the equipment.

### Common Failures

Because similar parts vary from one manufacturer and model to another, the list of general parts that will work in every device will be limited. Spare parts such as batteries, fuses, filters, light bulbs, electrical connectors, and patient accessories vary from device to device. Unless the healthcare facility where you are going has completed an inventory and evaluation of the medical equipment you will need to use, it will be close to impossible to anticipate what parts you should take with you to address problems. If, on the other hand, they evaluate their needs, you might be able to obtain a list of the parts to take. Therefore, asking for this information in advance is the only hope of obtaining appropriate spare parts to carry with you.

There are eight more common/critical devices that a surgeon will depend upon (Table 10.2). Three are specific to the operating room (OR) or surgery area (anesthesia, electrosurgical unit, and sterilizer), and the others will be found in the OR, postanesthesia care unit, ward, and/or other areas of the hospital.

## Troubleshooting Examples

The following two troubleshooting examples occurred in 2015 in two African countries and illustrate how to follow the four P's of troubleshooting.

The first example was a nerve stimulator in Uganda that the anesthesiologist simply said "is not working." Although the handheld stimulator had no power cord, one should still begin with the evaluation of the first "P" – power. It still requires

**Table 10.2** Common failures

| Problems | Solutions |
|---|---|
| Anesthesia machine | |
| Pneumatic leaks | Check all patient circuits, hoses, gaskets, connectors/fittings |
| Incorrect readings | Check sensors, electrical cables and connectors, batteries |
| Patient monitor | |
| Poor ECG signal | Check skin prep and electrode condition |
| Poor or incorrect BP readings | Check hoses, connectors, and patient cuff |
| Poor or incorrect $SAO_2$ reading | Check condition of finger sensor |
| Electrosurgical unit | |
| Alarm going off | Check patient plate wires, connectors, and contact with patient |
| Poor cut and/or coag | Check proper patient plate contact with patient skin |
| No cut or coag | Check footswitch and/or pencil condition |
| Oxygen concentrator | |
| Low airflow | Check all filters (external and internal) |
| Low $O_2$ percent (meter needed) | Check filters, proper power source, age of concentrator |
| Suction pump | |
| No or low suction | Check filters, hoses, suction adjustment |
| Running slow and/or hot | Check proper power source (specifically the frequency) |
| Defibrillator | |
| Will not operate if unplugged | Battery low or dead |
| Poor ECG signal or display | Check skin prep, electrodes, and patient cable |
| Pulse oximeter | |
| Will not operate | Check battery condition |
| No or poor patient signal | Check finger ($SAO_2$) sensor (connector, cable, sensor) |
| Sterilizer | |
| Will not come on or heat | Check power source. Check steam generator |
| Will not sterilize | Check door gasket, steam traps, and piping for leaks |

power to operate. Therefore, the 9 V battery was removed and checked with a meter. The battery was indeed low (4.5 V) and needed replacement. The second "P" (procedure) troubleshooting step was not evaluated because the doctor was known to be experienced in the proper operation of the stimulator. However, as a reminder, it is not logical or safe to always assume the user fully understands the operation of the device. The third "P" (evaluation of the patient accessories or interface) was then undertaken. In the case of this stimulator, it was designed with two lead wires that connect the stimulator to the patient. One of the two wires was broken and needed repair. The stimulator was now returned to full function. After following the four P's approach to troubleshooting, it was discovered that the stimulator failure was both a power problem and patient interface problem, and it was quickly and easily repaired and returned to service.

The second example was a patient monitor in South Sudan. The initial complaint by the clinical staff was a very poor ECG signal and display on the monitor. The QRS signal was barely visible and consisted of mostly interference or artifact. Since the monitor was on and all other parameters are functioning well, and it was a monitor designed to work on both 110 V 60 Hz and 220 V 50 Hz, it was assumed that the first P, power, was good. The next P, procedure, is often a problem with when there is a poor QRS signal on monitors. Therefore, the lead setting on the monitor and the lead placement on the patient were checked and found to be okay. However, the clinical staff admitted that the skin prep on the patient was not completed correctly when the electrodes were applied. Additionally, the patient electrodes were old and dried out. Once the skin was prepped correctly and new electrodes were installed, there was an improvement on the signal on the display. Nevertheless, the signal still had a significant amount of artifact. The next P, patient interface, was checked, and it was determined by the use of a simulator that the patient cable and lead wires were found to be good. At this point, it was assumed the final P, part, had failed in the monitor. Before concluding that the problem was an internal failure, there was one last attempt to troubleshoot the problem by going into the "advanced settings" mode of the monitor. This will not be easy if you are not familiar with the monitor and don't have a manual available. Fortunately, this function was found, and upon investigation, it was found to have a software setting to set the monitor for 50 Hz or 60 Hz operation. The monitor was set for 60 Hz but was plugged in to the typical 50 Hz African power source. Once the monitor setting was reset for 50 Hz, the frequency interference disappeared, and the monitor had a clean QRS display. Therefore, the problems were primarily procedures which included poor skin prep, an improper power setting, and patient interface (dried electrodes).

## Preventing the Failure

**The Essentials**

- *Everyone (admin, clinical, technical, and support staff) can help prevent failures.*
- *Appropriate technology procurement is the first step in preventing failures.*
- *Proper usage and handling of equipment is the next step in preventing failures.*
- *Developing and following an equipment management plan prevents most failures.*

Preventing future equipment failures and problems are often not considered or are left up to maintenance personnel. However, users and clinical staff play an important role in preventing a variety of failures. The three basic prevention steps include

**Table 10.3** The three P's of prevention

| | |
|---|---|
| Proper care | Handle the equipment carefully and keep clean |
| Performance check | Verify proper operation and performance before every use |
| Preventive service | Replace worn accessories and parts before they fail |

proper care and use of the equipment, evaluating the performance of the equipment each time it is used, and performing basic preventive service before the failures occur (Table 10.3).

Proper care of the equipment starts with proper cleaning and careful handling. All filters should be checked and cleaned on a regular basis. Some are designed to be blown out and/or washed, and some are disposable and will need to be replaced. Failure to keep air filters clean may result in equipment overheating and component failures. Dirty air filters on oxygen concentrators will also affect the oxygen output, and concentrators typically have both internal and external filters that will need cleaning and replacing. Some equipment, such as sterilizers, also have water and/or drain filters that must also be checked and cleaned on a regular basis. One very common failure with suction pumps can be traced directly to the filters. The most common filter problem on pumps is with bacteria filters that may appear to be just fine, but become clogged and prohibit airflow. A defective bacteria filter can be easily verified by simply bypassing the filter to test.

Being proactive with your facility by encouraging the addition and regular use of protection devices against "bad" electricity can go a long way toward prevention of unwanted damage from bad power. A simple inexpensive surge protector can reduce or eliminate damage caused by short-term spikes coming into your medical equipment's power cord. Lightning and other surge currents caused by "noisy" equipment being used nearby can send thousands of volts of a very short duration that may not blow the protective fuse, but will damage delicate electronics contained within your ultrasound machine or patient monitor. These simple plug-in devices isolate your medical equipment from spikes simply by clamping the incoming current at a manageable voltage.

Sustained low voltage (commonly called "brownouts") forces many medical devices to try and compensate by increasing their draw of current from the line. This generally overheats your suction pump motor or compressor unit. Voltage correction transformers sometimes called regulators are step-up/step-down transformers that can maintain the proper operating voltage when your source becomes lower or higher than normal. These units cost more but will pay for themselves many times over. Brownouts are common in LMIC and can be as dangerous as unprotected power surges to electronic equipment.

The ultimate power protection device is an uninterruptible power supply (UPS). These devices contain a storage battery and inverter that produce their own power that is clean and carries you through both "brownouts" and complete power losses. The UPS will continue to operate until the battery loses its charge. This gives the clinician time to complete the surgery case or the ultrasound study without

**Fig. 10.6** This electrosurgical unit/Bovie pencil connector was damaged from an improper cleaning solution

interruption. These UPS units must be sized according to the load being provided but are generally available in many developing countries city centers. They are the most expensive solution and can be bulky, but properly sized, they can provide clean power for everything from cell phone chargers to CT scanners.

Cleaning should be performed for obvious reasons, including infection control and damage from dust and dirt. Make sure the cleaning materials or fluids are appropriate and will not cause damage to the device or accessories. Improper cleaning procedures or materials could result in damage such as the electrosurgical unit pencil connector (Fig. 10.6). The contacts corroded because the users plugged in the pencil when it was still wet with a corrosive cleanser, and this resulted in a poor connection between the pencil and the device.

Proper care and handling of the equipment and accessories is essential. The patient accessories or interface devices are the weakest link in medical equipment. Therefore, all users must treat the devices and accessories with respect and understand they are susceptible to easy breakage. An example of how not to care for the patient accessories is shown in Fig. 10.7. Pulling on cables, hoses, and wires and/or wrapping them too tightly will cause internal breakage of wires that cannot be seen or leaks in hoses and connectors. Clinical staff should be trained and reminded of the importance of proper care.

**Fig. 10.7** This is not the correct care and handling of patient accessories. Note the kinked blood pressure hose near the connector

## Encourage the Development of a Medical Equipment Management Plan

US healthcare regulations require regular performance and safety (PAS) inspections. This is not optional in the USA and insures patient safety and properly operating equipment. PAS inspections and tests can be performed by both the users of the equipment and biomedical technicians. These inspections fall primarily on the clinical staff in most limited-resource countries where there are no available biomed techs. Prior to using a medical device on a patient, the user should visually and functionally inspect the device and verify it is performing properly.

US healthcare regulations also require regular preventive maintenance (PM). This is also occasionally referred to as planned preventive maintenance (PPM). Although PMs are typically carried out by biomedical technicians, preventive service can and should be performed by the clinical staff when biomed techs are not available. Preventive maintenance means replacing parts before they fail. These types of parts are typically mechanical parts that wear out, for example, clogged filters, and/or the patient accessories that wear out over time and usage. Lubrication of mechanical parts is also considered a PM. The lack of ready availability and the expense of replacing a part that is "still working" make this difficult to implement in limited-resource areas and cultures.

Procurement of appropriate technology (medical equipment, parts and accessories) is one of the most effective ways of preventing problems. Whether or not you are personally involved with procuring medical equipment, parts, or accessories or you have the opportunity to make recommendations to the healthcare facility where you are working, make sure you know the source of the equipment or parts. As mentioned earlier, "a large proportion (up to 70 per cent) of equipment lies idle due to mismanagement of the technology acquisition process" [4]. This is a result of using donors or providers that are not familiar with appropriate technology transfer to LIMC environments. Even though the provider has good intentions and wants to help, their available equipment and/or parts may not be suitable for the environment to which it will be sent.

One way to ensure you are obtaining the most appropriate technical resources and support is by utilizing organizations and individuals that adhere to quality standards and have experience working in LMIC environments. Technical Exchange for Christian Healthcare (TECH) is one example of an association of many healthcare organizations and individuals who follow quality standards. "Sharing their resources, knowledge, and expertise, TECH members are committed to providing functioning, appropriate, sustainable medical equipment. Believing that our work reflects our Christian testimony, TECH members are attentive to the quality of items sent to the mission field" [6]. These "standards" [7] help insure the technology will be most appropriate for the environment and application it will be sent to and that all aspects of the transfer (packing, shipping, installation, training, parts and manuals, etc.) will be carefully considered. For a list of the current TECH members with links to their websites, go to www.techmd.org/membership/. These members include:

- Chosen http://www.chosenima.org/
- International Aid http://www.internationalaid.org/
- Samaritan' Purse http://www.samaritanspurse.org/

## Summary

Anticipate and plan for equipment problems before and during your time of service. Plan ahead and take any critical devices, accessories, or supplies that you anticipate needing if there is no guarantee that they will be available on-site when you arrive. Expect that you will encounter existing problems and some will develop while you are there. Follow the four P's of troubleshooting to ensure a quick and most effective resolution to these problems.

Prevent future problems by performing preventive service and encouraging the national staff or hospital management to seek appropriate future procurement and service.

Lastly, seek help from those with international medical technology support experience. This should be done before, during, and after your travel to the field. Encourage hospital leadership to manage their technology correctly the first time and not put Band-Aids on their problems.

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