DEVELOPMENT OF A REUSABLE PATIENT BLANKET FOR A FORCED-AIR PATIENT WARMER

Gordon McConnell, P.Eng.
Biomedical Engineering Department, Vancouver/Coastal Health Authority
Charles Xiao, B. Eng, MHA,
Biomedical Engineering Department, Vancouver/Coastal Health Authority

Abstract

A forced-air patient warming system is used at Vancouver General Hospital to warm surgical patients. Special disposable patient covers (blankets) are used with the warmers to distribute warmed air over the patient. These disposables add over $150,000 to the Hospital's operating budget. Because of the cost of the disposables, Hospital staff have been substituting layered flannel sheets for the disposable blankets, a practice that does not always provide as effective warming and under some circumstances, may be unsafe. As an alternative to the disposable blanket, the Biomedical Engineering Department has developed a washable fabric blanket that works as well as the disposable blanket with a cost per use that is 80% less. This cost includes manufacture, laundry, inspection, replacement if necessary, and delivery. Although the reusable blanket is an effective, safe, and economical alternative to the disposable blanket, a number of issues have delayed the introduction of the product.

Discussion

Warming of intra-operative and post-operative patients lowers the risk of bacterial infections and reduces patient recovery time. Using a forced-air (convective) patient warming system has gained acceptance for this purpose as it applies heat to the patient with lower risk than alternatives such as a hot water bottle, fluid-filled heating blanket, or electric heating pad.

A forced-air warming system consists of an electric heater and blower unit (referred to hereafter as the blower), and a patient cover (blanket). Warmed air is blown between the two layers of the cover that are attached and sealed along the edges. The layer that is placed against the patient is more porous resulting in the warmed air being directed onto the patient.

Warmth is produced by two distinct mechanisms: radiant shielding and convection. Radiation is usually the dominant mechanism of intra-operative and post-operative heat loss and is the photon-mediated transfer of heat between two nonadjacent surfaces. One surface is the skin, and the other is a solid surface in the environment such as the ceiling or the walls. The forced air system reduces radiant heat loss simply by replacing the cool surfaces of the room with a warm cover.

Convection is the second most important mechanism of heat loss. It is also called *facilitated conduction* because conduction to still air, which is an excellent insulator, is increased by orders of magnitude when the air moves rapidly over the skin. When the air is colder than skin, convection increases heat loss - the familiar wind-chill factor. However, convection similarly increases heat gain when the air is warmer than skin. Forced-air warmers take advantage of this phenomenon by producing a flow of warm air across the skin.

VGH has been using forced-air patient warmers for almost 10 years for intra-operative and post-operative warming of patients. The Hospital purchases disposable blankets from the manufacturer of the warmers under a contract in which the Hospital gets the blowers on loan provided a predetermined number of these single-use blankets are purchased. In order to reduce this expense, the Anesthesia Department staff began placing the hose from the blower

between flannel sheets instead of using a disposable blanket. Recognizing that this system was not very effective because much of the warmed air simply flowed out from between the edges of the flannel sheets, the staff began folding the edges of sheets over one another. The performance of this use of flannel sheets was encouraging and the Departments of Anesthesia and Biomedical Engineering began investigating the availability and economy of a reusable blanket. Only two manufacturers of reusable blankets could be found. Both manufacturers were out of country and neither offered their product for sale in Canada. At this point, the Departments began looking into the custom manufacture of the blankets.

Biomedical Engineering designed and made a prototype blanket from the flannel sheets used in OR. Its performance was comparable to that of the disposable blankets. The parameters tested were the temperature of the warmed air from the blower, the pressure of the air in the blanket, and the duty cycle of the heater. The company providing laundry services to the Hospital, K-Bro Linen Systems Inc., offered to manufacture the blankets for the Hospital at no charge. The Hospital would then be charged about 20% the cost of a disposable to launder the product. The company will pick-up the soiled blankets, sort and separate the blankets from the other laundry, launder them, visually examine both sides on a light table, replace them if necessary, sterilize the products if required (for an extra charge), and deliver them to the clinical areas requesting them. The company provided six prototypes that were trialled clinically (for 10 laundry cycles) with successful results. K-Bro made a number of improvements to the original design.

The K-Bro prototypes were tested and compared to disposable product with the following results.

- The temperature produced with a prototype and with a disposable is shown in Figure 1. The temperature with the reusable blanket is slightly higher than that with the disposable product, but still within the temperature setting of the blower.
- The pressure developed in the blanket by the blower is lower with the reusable product than with the disposable (0.30 mmHg versus 0.45 mmHg). The impact of this difference on the fan and the heater is not clear. There is no empirical indication that lower pressure will damage the blower.
- The difference in the voltage off-to-on ratio of the blower heater is shown in Figure 2. The power dissipation in the blower heating components will be higher when the blower is used with the reusable product. However, infrared pyrometry did not show a measurable increase in temperature in the solid-state relays.
- The susceptibility to ignition by an electrosurgical unit of both the reusable and disposable blankets was tested. Both took repeated activation of the electrosurgical unit at high power before they ignited. No difference in the susceptibility of the products to ignition was discernable.

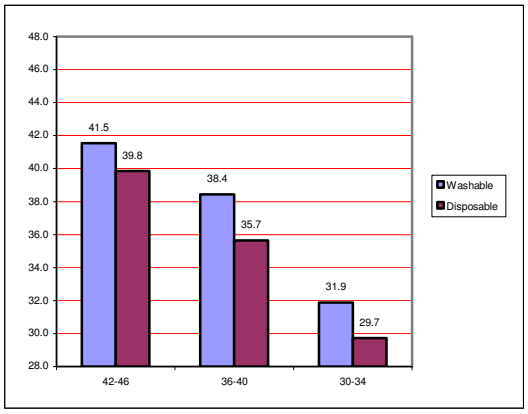

Figure 1. Temperature output comparison by temperature settings

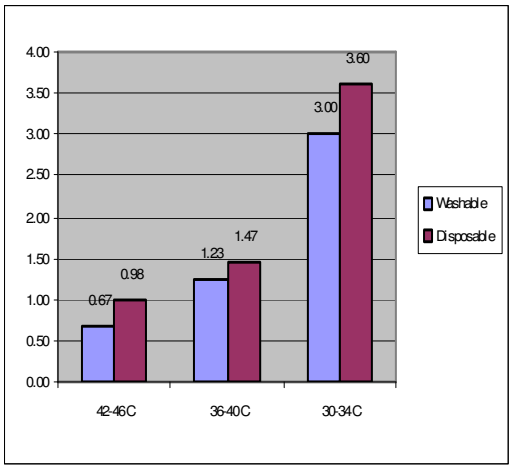

Figure 2. Comparison of Off/On ratio of the heater of the blower

Issues

Contractual

VGH currently get the blowers for the forced-air patient warmers on loan at no cost. If the Hospital uses reusable blankets, the blowers would have to be purchased. The cost of purchasing the blowers would be recovered in less than a year from the savings.

Patient safety

Relatively few incidents of patient burns are reported in available medical device incident databases when compared to the number of procedures in which forced-air patient warmers have been used. Of those reported, many resulted from improper use of the warmer. The technology is safe provided that the warmers are used according to the manufacturer's instructions. The use of a reusable blanket should not introduce any additional risk to the patient.

Risk of Patent Infringement

Patents exist regarding forced-air warmers that include the blanket. The product that VGH has been developing has significant differences than those in the patents that we are aware of. VGH has engaged a company to assure that there will not be any patent infringements.

Medical Device License Requirement

Since the blower of the patient warming system is classified as a Class II medical device by Health Canada, the blanket connected to it is also considered a Class II device. We are negotiating with a medical device manufacturing company to make the blankets for the Hospital and to obtain a medical device license for the product.

In Summary

The reusable blankets will be introduced into the peri-operative areas of the Hospital this summer. The delay in bringing this product from conception to clinical use has been frustrating for those in the Biomedical Engineering Department that are involved in the project. However, the experienced gained is valuable and will help reduce the delays and streamline subsequent projects.