Evaluation of an antimicrobial surgical glove to inactivate live human immunodeficiency virus following simulated glove puncture

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Background. *Percutaneous injuries associated with cutting instruments, needles, and other sharps (eg, metallic meshes, bone fragments, etc) occur commonly during surgical procedures, exposing members of surgical teams to the risk for contamination by blood-borne pathogens. This study evaluated the efficacy of an innovative integrated antimicrobial glove to reduce transmission of the human immunodeficiency virus (HIV) following a simulated surgical-glove puncture injury.*

Methods. *A pneumatically activated puncturing apparatus was used in a surgical-glove perforation model to evaluate the passage of live HIV-1 virus transferred via a contaminated blood-laden needle, using a reference (standard double-layer glove) and an antimicrobial benzalkonium chloride (BKC) surgical glove. The study used 2 experimental designs. In method A, 10 replicates were used in 2 cycles to compare the mean viral load following passage through standard and antimicrobial gloves. In method B, 10 replicates were pooled into 3 aliquots and were used to assess viral passage though standard and antimicrobial test gloves. In both methods, viral viability was assessed by observing the cytopathic effects in human lymphocytic C8166 T-cell tissue culture. Concurrent viral and cell culture viability controls were run in parallel with the experiment's studies.*

Results. *All controls involving tissue culture and viral viability were performed according to study design. Mean HIV viral loads ($log_{10}TCID_{50}$) were significantly reduced ($P < .01$) following passage through the BKC surgical glove compared to passage through the nonantimicrobial glove. The reduction (log reduction and percent viral reduction) of the HIV virus ranged from 1.96 to 2.4 and from 98.9% to 99.6%, respectively, following simulated surgical-glove perforation.*

Conclusion. *Sharps injuries in the operating room pose a significant occupational risk for surgical practitioners. The findings of this study suggest that an innovative antimicrobial glove was effective at significantly ($P < .01$) reducing the risk for blood-borne virus transfer in a model of simulated glove perforation. (Surgery 2013;153:225-33.)*

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The Centers for Disease Control and Prevention has estimated that more than 1,000 injuries involving sharp objects occur daily in US hospitals, placing health care workers at risk for a myriad of blood-borne pathogens, including human immunodeficiency virus (HIV), hepatitis B virus, and hepatitis C virus (HCV).[1] Members of surgical teams are known to have higher rates of percutaneous injury than individuals in other health care settings: the probabilities of blood exposure are high; the natures of the surgical procedures often dictate the use of multiple sharp instruments in tight or confined quarters; sharps injuries may occur while devices such as sutures or needles are manipulated or passed among members of the surgical team; and stressful intraoperative events may occur, momentarily distracting attention from sharp objects within the surgical field.[1-3] Following passage of the Needlestick Safety and Prevention Act

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in 2001, there was a significant drop (31.6%) in the sharps injury rate within the nonsurgical setting; however, over the same time interval a 6.5% increase in sharps injuries was noted in the operating room environment.[4,5] The devices most often associated with injury include suture needles, scalpel blades, and syringe needles. These findings suggest that compared to other areas of the hospital, operating rooms have been less compliant in adopting engineering controls that would reduce the risk for sharps injuries.

In an effort to mitigate the risk for sharps injuries in the operating room, the American College of Surgeons (ACS) in 2005 issued a position statement supporting the adoption of blunt suture technology for fascia closure.[6] Although these devices have been shown to be effective in reducing sharps-related injuries, this technology has not been universally embraced by surgical practitioners, and although the devices themselves do not have cutting edges, the proximal (pointed) tip of the suture can still penetrate surgical gloves.[7,8] The ACS Committee on Perioperative Care has also endorsed the practice of double-gloving as a technique of reducing exposure to body fluids caused by tears in gloves caused by sharps. It has been estimated that double-gloving can reduce the volume of blood transferred when a contaminated needle or suture passes through the 2 glove layers by as much as 95%.[9] In spite of the data supportive of double-gloving as an effective risk-reduction strategy, many surgeons feel that double-gloving reduces hand sensitivity and dexterity, so the practice has seen limited application. A third intervention, endorsed by the Occupational Safety and Health Administration, ACS, and the Association of periOperative Registered Nurses, involves the concept of the neutral zone, or the hands-free technique, in which objects are not passed between individuals by hand during surgery but rather are placed on a designated area of the sterile field.[10-12] In spite of these collective endorsements, sharps injuries in operating rooms remain problematic, especially in high-volume surgical services involving high-risk patient populations.

The present in vitro study has been designed to evaluate the effectiveness of an innovative antimicrobial surgical glove in reducing live HIV-1 infectious viral transmission following simulated, severe percutaneous occupational injury.

MATERIALS AND METHODS

Standardized puncture technique. The test conditions were designed to simulate an accidental occupational exposure involving a 6 mm–depth puncture using a 22-gauge hollow-bore needle filled with blood containing live HIV-1 virus. Briefly, the puncture apparatus consists of a pneumatic actuator, supporting a needle and syringe mounted on a vertical scale, allowing accurate control of the puncture depth and angle (Fig 1, *A*). Air pressure regulated by a manometer controlled the puncture speed, allowing for a high degree of reproducibility. Two different surgical gloves were tested in the apparatus; an integrated 3-layer elastomeric antimicrobial glove containing in its core homogenously distributed micrometer-sized liquid droplets (Fig 2) composed of 30% benzalkonium chloride (BKC) in polyethylene

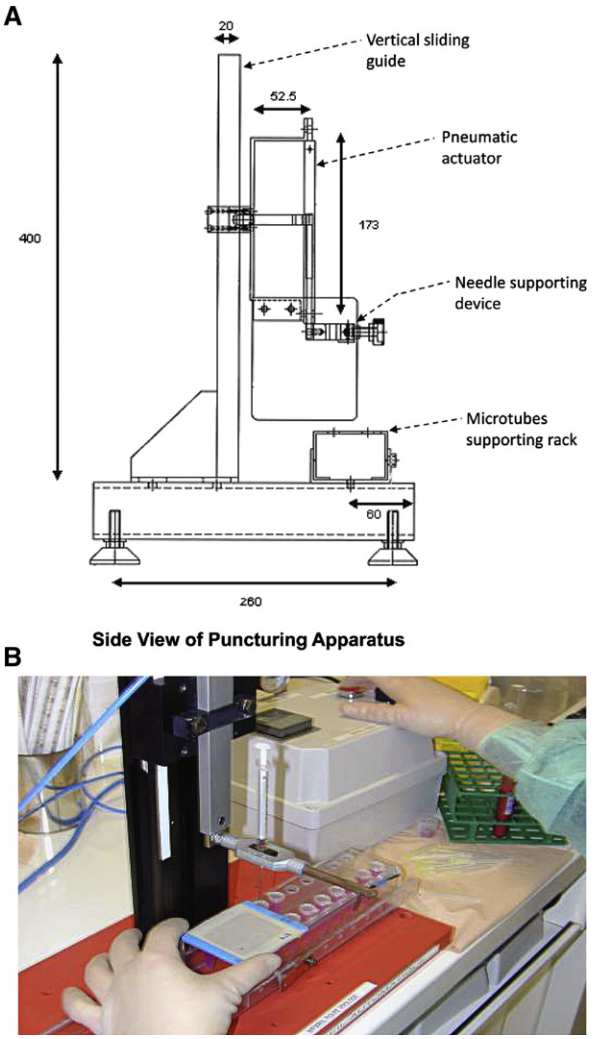

Fig 1. (*A*) Side-view schematic of glove-puncturing apparatus, demonstrating vertical guide, pneumatic actuator, needle support, and microtube support rack. (*B*) Picture of investigator using pneumatic glove-puncturing device, demonstrating positioning of glove segments above microtube support rack. (Color version of figure is available online.)