Contaminated operating room boots: The potential for infection

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Background: Dirty operating room boots, often contaminated with blood and other infected material, are not only a source of discontent among surgeons and other surgical personnel, but they also pose a potential risk of transmission of viral or bacterial diseases to the wearer and cleaner of the boots.

Method: Operating room boots were examined for the presence of blood by visual inspection; the presence or absence of blood was confirmed by a specific biochemical test. Bacterial isolation and quantification from boots were performed with conventional methodology.

Results: In this study, a spot check revealed that 44% of all operating room boots tested were contaminated with blood and that the majority were contaminated with bacteria. Sixty-three percent of surgeons using the facility had blood-contaminated boots, and a significant number of boots belonging to other surgical personnel were also contaminated with blood and bacteria normally associated with skin microbiota or the environment. Comfort shoes with perforations on their upper surface and plastic boots commonly found in operating rooms were most heavily contaminated, whereas Wellington boots and clogs had less contamination.

Conclusion: The present practice of manual cleaning of boots is unsatisfactory, and it is recommended that boots be washed in automatic washing machines. (Am J Infect Control 2002;30:179-83.)

During the course of many surgical procedures, especially after urologic and gynecologic operations, blood and other body fluids from the patient contaminate the boots of surgeons and other surgical personnel (Fig 1). Our contention is that in most operating rooms in the United Kingdom there is no recognized satisfactory arrangement for cleaning these boots. Many surgeons and other surgical staff resort to cleaning the boots themselves, whereas the vast majority resign themselves to the fact that they are only occasionally cleaned by custodial staff. With the recent awareness that many viruses—HIV and hepatitis B and C viruses in particular—can survive in dry blood for up to 5 weeks and possibly longer,[1] the process of cleaning boots by operating room and custodial staff without adequate precautions could well present potential risk of transmission to the personnel involved. The aim of this article is to highlight these risks and to consider a possible solution.

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METHODS

In this study, operating room boots were examined for the presence of blood on their upper surface by visual inspection; the presence or absence of blood was confirmed by a specific biochemical test. To investigate the degree of microbial contamination of boots, swabs were taken from the upper surface and sole and were cultured for bacteria. Cell cultures were not inoculated for the detection of viruses.

We examined 54 pairs of boots used in the main operating rooms of our district general hospital. The 4 surgical suites are used for a wide range of routine major surgical procedures in general surgery; urology; gynecology; and plastic, thoracic, and orthopedic surgery and include a 24-hour emergency service in these specialities. No prior warning for this study was given, and the boots were examined for blood and microbiologically when all the routine cleaning procedures in the operating rooms were complete and the boots were ready to be used for the following day's operat-

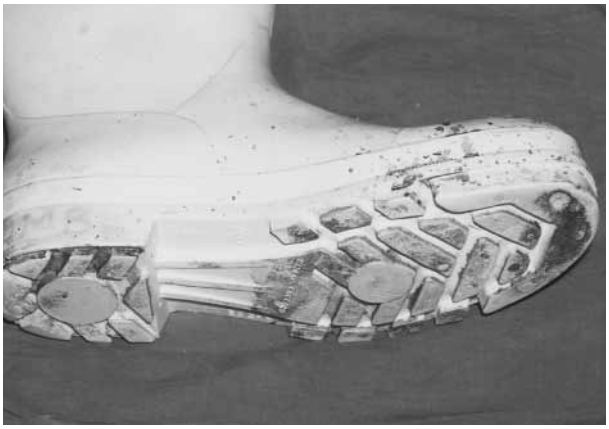

Fig 1. Operating room boot contaminated with blood.

Table 1. Presence of blood* on the surface of boots and bacterial colony-forming units (CFU/cm^2) on the surface and soles of boots from different grades of surgical staff

Grade	Blood* Present (%)	Total count CFU/cm^2 Mean (SD) Upper	Sole
Surgeons (n = 16)	10 (63%)	35 (61)	132 (189)
Anesthetists (n = 13)	4 (31%)	48 (136)	107 (135)
ODAs (n = 7)	3 (43%)	16 (17)	160 (166)
Nurses (n = 7)	3 (43%)	90 (182)	161 (168)
Visitors (n = 11)	4 (36%)	48 (54)	283 (207)

ODAs, *Operating department assistants.*
*Assessed with the LMG test.

ing lists. The speciality and status of the owner of each pair of boots were noted. A few "unnamed" boots usually used by visitors to the operating room were also examined. The type of boot, presence or absence of perforations on the upper surface, and the depth of tread were noted for each pair. The footwear examined were of the following types: Wellington boots (calf-length boots made of polyvinyl chloride with a significant tread pattern on the soles); plastic boots (backless slip-on shoes made of plastic, some of which have perforations on the upper surface); comfort boots (similar in style to plastic boots but with polyurethane-coated upper soles); clogs (polyvinyl chloride-coated leather uppers with no perforations and with a wooden sole). The presence of any visible blood on the surface of the boot was recorded, and a wet swab was taken from the surface of the left boot of each pair to detect the presence of blood with the leuco-malachite green (LMG) test. The LMG test used was as described by Thomas et al,[2] with slight modifications. Briefly, swabs taken from the boots were soaked with LMG solution (1 g LMG; 5 g powered zinc; 150 mL glacial acetic acid, and 100 mL distilled water), and a solution of 3% hydrogen peroxide was added. A deep blue discoloration, noted within 5 minutes of exposure, indicated the presence of blood on the swab, whereas in the absence of blood, the swab remained colorless. To detect the presence of bacteria, an area of 1 cm^2 was sampled with use of a plastic template and a moistened swab from the right boot of each pair. The swab was inoculated onto nutrient agar (Oxoid Ltd, Basingstoke, Hampshire, United Kingdom) and incubated for 48 hours at 37°C under aerobic conditions. Colonies were counted, and representative colonies further were examined to identify the organisms cultured by conventional methods.

RESULTS

Overall, 44% (24/54) of all the operating room boots tested were contaminated with blood, as determined by the LMG test. Table 1 shows the presence or absence of detectable blood on boots belonging to different grades of surgical staff. The boots of 63% of surgeons, 43% of operating department assistants, 43% of nurses, 36% of visitors, and 31% of anesthetists were contaminated with blood.

Quantification of bacteria by total colony counts showed that the majority of the upper surface and soles of surgical staff boots were contaminated with significant numbers of bacteria (see Table 1). Table 2 shows the detection of blood on the boots of surgeons from different specialities. Although the sample size was small, virtually all of the boots of surgeons from the different specialities demonstrated contamination, as evidenced by the total counts recorded. Furthermore, in this study, 80% (4/5) of consultants and 55% (6/11) of registrars had boots on which blood was detected and the colony counts suggested that most were contaminated with bacteria.

The validity of the methods used to detect the presence of blood was evaluated. The results in Table 3 compare the LMG test with visual assessment. The sensitivity of the LMG test was 68%; the specificity was 76%, with 7 false-negative and 8 false-positive results.

Table 4 shows the bacterial contamination of boots in relation to the type of boot, presence or absence of perforations on the upper surface of the boot, and the depth of tread on the sole. Identification of the

Table 2. Presence of blood* and bacterial colony-forming units (CFU/ cm^2) on boots from surgeons of different specialities

Speciality	Blood* Present (%)	Total count CFU/cm^2 Mean (SD) Upper	Sole
General surgery (n = 4)	2 (50%)	54 (98)	141 (240)
Urology (n = 5)	3 (60%)	32 (41)	134 (205)
Gynecology (n = 2)	2 (100%)	10 (7)	3 (4)
Orthopedic (n = 2)	1 (50%)	75 (106)	60 (57)
Thoracic (n = 3)	2 (67%)	3 (6)	250 (229)

*Assessed with the LMG test.

Table 3. Visual assessment for the presence or absence of blood (V+ and V-) compared with the LMG test (T+ and T-)

	T+	T-	Total
V+	17	8	25
V-	7	22	29
Total	24	30	54

Table 4. Bacterial colony counts (per cm^2) on operating room boots in relation to depth of tread, presence or absence of perforations, and type of boot

	Sole Mean (SD)	Upper Mean (SD)
No tread (n = 27)	197 (192)	N/D
2-3 mm tread (n = 19)	118 (149)	N/D
Deep tread (n = 8)	163 (209)	N/D
Perforations + (n = 28)	N/D	66 (133)
Perforations - (n = 26)	N/D	24 (35)
Wellingtons (n = 10)	143 (191)	18 (32)
Clogs (n = 5)	64 (79)	19 (14)
Comfort boots (n = 30)	147 (174)	40 (98)
Plastic boots (n = 7)	357 (162)	125 (177)

N/D, Not done.

representative colonies showed that most of the organisms cultured were associated with normal human skin microflora and environmental contamination. *Staphylococcus saprophyticus, Streptococcus saprophyticus, Sarcina saprophyticus,* and *Bacillus saprophyticus* were all isolated. *S aureus* was isolated from 1 pair of boots, *S haemolyticus* from 2 pairs, *S epidermidis* from 1 pair, and yeast from 2 pairs.

DISCUSSION

Recent studies have shown that viral markers for HIV and hepatitis B and C could be detected in discarded contaminated syringes, needles, and swabs for up to 5 weeks and possibly longer.[1] The effectiveness of chemical disinfectants against viruses in clinical settings has been overestimated,[3] and some of them (isopropanol and ethanol) leave some viable infectious HIV-1 particles after a 30-minute treatment with 70% solutions.[4] The same authors[4] also reported that at a pH of 7.1, the half life of HIV-1 virus ranged from 24 hours at 37°C to no significant loss for 6 months at 75°C . Furthermore, chemical disinfectants need to be applied to clean objects and surfaces, or they are inactivated. Although the risk of contracting HIV or hepatitis B or C from contaminated objects is very small, we cannot ignore the potential risk. Blood-contaminated operating room boots could be a source of transmission of these viruses from handling and cleaning by domestic, medical, or nursing staff if adequate precautions are not taken. If an uninformed member of the domestic staff who cleans operating room boots contracts any of these viral diseases, he or she may have a case for future litigation. With the exception of gloves, which are seldom used, domestic staff are not provided with any additional protective apparel.

This preliminary study shows that 44% of all operating room boots were contaminated with blood, mostly comprising of surgeons' boots (63%), which is perhaps to be expected, but also a good number of other surgical staff and visitors' boots were contaminated with blood. Among different specialities, gynecologists' had the highest rate of blood-contaminated boots compared with other specialists. Interestingly, gynecologists' boots had the least number of bacteria (CFU/cm^2), suggesting that the extent of bacterial contamination is a poor predictor of blood contamination. It was clear that visual assessment of boots that might possibly be contaminated with blood was not as reliable as the chemical method used. Sole reliance on the visual assessment of blood on the surface of boots was unreliable since there was a 29% incidence of false-negative results.

Most bacteria isolated during this study were nonpathogenic members of the skin microbiota or environmental organisms. The colony count of bacteria was greatest on the upper surface of comfort boots with perforations, normally worn by nurses. Although this study was small and needs to be confirmed with a larger sample size, clearly this design of boot harbors significant numbers of bacteria, probably

because of the difficulty in cleaning them. Perhaps this type of boot should be abandoned, but they are very popular with surgical nurses who wear them for long hours every day and are therefore reluctant to discontinue their use. Bacterial contamination of soles was highest among visitors, followed by the boots of operating department assistants, who usually work away from the operating field. This may have been as a result of general failure to clean these boots.

The cleaning of boots is generally ignored in modern operating room cleaning protocols and is often delegated to the domestic staffs who apply their own judgement in choosing which of them require cleaning. This cleaning is often dependent on their motivation and the time they are given to do this task when they are free from other duties. The result is irregular and inadequate cleaning of boots, which is often a source of dissatisfaction among surgical staff who consider themselves fortunate to have this cleaning service. Their nursing colleagues are often denied this service and are supposed to clean their own boots. Visitors to the operating rooms (mostly locums, medical students, nursing students, radiographers) often have a tendency to find the cleanest pair of boots available in the locker room. To avoid this use by other individuals, surgical staff prefer to keep their boots inside their lockers rather than to leave them out for cleaning!

The presence of nonpathogenic members of the skin microbiota and environmental bacteria, in relatively high numbers, indicates a poor degree of cleanliness, and one would wonder whether such high levels of contamination are acceptable in an operating-room setting. In most operating rooms in the United Kingdom in recent years, stringent precautions have been relaxed, and staff wearing regular outdoor shoes are allowed to enter the anesthetic room. In these circumstances, high colony counts of bacteria on boots used in operating rooms are not considered alarming and may be acceptable (albeit a possible source of methicillin-resistant staphylococcus aureus). However, we surely cannot ignore the high level of blood contamination of operating room boots, reported here, which have the potential to transmit viral infections to the patient as well as wearer and cleaner of the boots.

Our study showed that upper surfaces of Wellington boots and clogs were the least contaminated, possibly because of their shiny and slippery surface, to which bacteria are unlikely to attach. However, they are uncomfortable for surgical nurses who have to wear them for long hours each day. Comfort shoes with perforations are more likely to be contaminated with bacteria, and plastic boots had very high colony counts due to a combination of the presence of perforations and the plastic material. Perforations on the upper surface of boots could potentially contaminate the feet with blood and infected material. It appeared that the depth of tread on the boots examined was not related to the extent of bacterial contamination.

This study was performed on consecutive Wednesday nights and is therefore representative of the contamination encountered during the middle of the week in a busy 24-hour operating room. A pilot study before this investigation undertaken on a Sunday morning also revealed similar results.

An extensive literature search revealed only 1 such study performed earlier in which this problem was addressed, and it was found that 36%, 40%, and 57% of boots examined in 3 different hospitals were contaminated with blood.[2] In the United States, where shoecovers are routinely used in operating rooms, concerns have been raised in 1 study regarding blood-saturated permeable shoecovers, which could lead to blood contamination of the skin of surgical staff.[5] In the United Kingdom, the single-use disposable shoecovers available are not well fitting and are clumsy and tend to be used only for the short walk in or out of the operating room and not for longer sessions.

We recommend the use of Wellington boots and clogs in operating rooms. Comfort shoes without any perforations on their surface are a comfortable alternative. Operating room boots should be cleaned daily after use, irrespective of their appearance. Ideally, boots should be washed with disinfectants in purpose-built automatic washing machines,[2] which are commercially available. The staff responsible for cleaning should be provided with some protective clothing, such as gowns, gloves, and goggles. Cleaning boots in washing machines, however, will require consideration of a type of boot that is quick to dry. Daily washing of boots will decrease their lifespan, and resources will need to be found for regular replacement. Shoecovers are a useful alternative, but in specialities in which much operative work is done with the aid of foot controls, an ill-fitting shoecover may not be practical. Elasticized, impermeable, and well-fitting disposable shoecovers in different sizes—midcalf level for Wellington boots and ankle high for other type of boots—are the best solution. However, studies have shown that shoecovers can contaminate the hands with blood[5] or with

organisms that would have otherwise been left on the floor,[6] and therefore, donning and removing shoecovers with gloved hands before leaving the operating room has been suggested.[5,7] Removal of boots after surgical sessions should always be performed with gloved hands. Until shoecovers are made widely available, the task of cleaning operating room boots should be undertaken by designated and fully informed surgical staff, who should take all necessary precautions. Visitors to the operating room should be given a pair of boots that are specifically kept aside for this purpose, and these boots should be cleaned after each use.

References

1. Cattaneo C, Nuttall PA, Sokol RJ. Detection of HIV, hepatitis B and hepatitis C markers in discarded syringes and bloodstains. Sci Justice 1996;36:271-4.
2. Thomas JA, Fligelstone LJ, Jerwood TE, Rees RWM. Theatre footwear: a health hazard? Br J Theatre Nurs 1993;3:5-9.
3. Satter SA, Springthorpe VS. Survival and disinfectant inactivation of the HIV virus: a critical overview. Rev Infect Dis 1991;13:430-47.
4. Tjotta E, Hungnes O, Grinde B. Survival of HIV-1 activity after disinfection, temperature and pH changes or drying. J Med Virol 1991;35:223-7.
5. Summers PR, Biswas MK, Portera SG, Moore L. Blood-saturated operating-room shoe covers. West J Med 1992;157:184-5.
6. Humphreys H, Marshall RJ, Ricketts VE, Russell AJ, Reeves DS. Theatre overshoes do not reduce operating theatre floor bacterial counts. J Hosp Infect 1991;17:117-23.
7. Rubio PA. Blood-saturated shoe covers. West J Med 1992;157:591.