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Hazards to surgeons in trauma and elective orthopaedic surgery: use of an electronic device to warn of intraoperative glove perforations

A J Hamer MB ChB
Senior House Officer
Department of Orthopaedic Surgery, Bristol Royal Infirmary

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An electronic device intended to detect glove punctures as they occur peroperatively has been described previously. This study reports the experience of its use in 80 orthopaedic cases. The device detected all punctures, except one, where fluid could have contacted the surgeon's hand ($n=16$). Wet gowns and drapes are potential routes for transmission of pathogens, and were responsible for the alarm sounding on 30 occasions. This device can minimise the exposure to potentially hazardous body fluids when glove punctures are not clinically apparent.

Surgical gloves were first introduced by Halsted 100 years ago and have been employed primarily to maintain wound sterility. They are, however, relatively inefficient at resisting puncture and recent studies have demonstrated rates of puncture of up to 50% *(1,2)* with the surgeon being unaware of the puncture in one-half of the cases *(3)*.

Recently, interest has concentrated on the role of intact gloves in diminishing the risk to surgeons of contracting hepatitis B and human immunodeficiency virus (HIV) from patients.

I have previously described a device whereby a surgeon may be warned as soon as he is in direct contact with the patient's body fluids, such as occurs if a glove is punctured or if a wet gown touches the patient's wound *(4)*.

A prospective study of its use in 80 traumatic and elective orthopaedic surgical cases is reported.

Correspondence to: Mr A J Hamer, 69 Spooner Road, Broomhill, Sheffield S10 5BL

Materials and methods

Circuit design

The system monitors the electrical resistance between surgeon and patient. This is reduced either if a glove is punctured, or if the patient's drapes and the surgeon's gown both become wet, or allowing the patient's body fluids to come into contact with the surgeon's skin *(4)*.

The resistance is measured between an ECG electrode worn by the surgeon and a similar ECG electrode on the patient. When this resistance falls, a buzzer sounds (Fig. 1).

At the beginning of each case, the surgeon attaches an ECG electrode to his back, before scrubbing. The wire to the device falls to the ground beneath his sterile gown. A similar electrode is attached to the patient, in any convenient position away from the sterile field, before preparation and draping. The leads of both surgeon and patient are plugged into the unit before the first incision.

Operations

The device was used during 65 elective and 15 traumatic orthopaedic cases (Table I). Each occasion on which the device was used was supervised by the author.

In the event of the alarm sounding, the surgeon's gloves were changed and were inspected for punctures both visually and by inflating with water. When squeezed, a jet of water would reveal a puncture.

In the event of no glove perforation being seen, the gowns and drapes were examined for areas of damp contact between surgeon and patient.

At the end of each case, after wound closure and

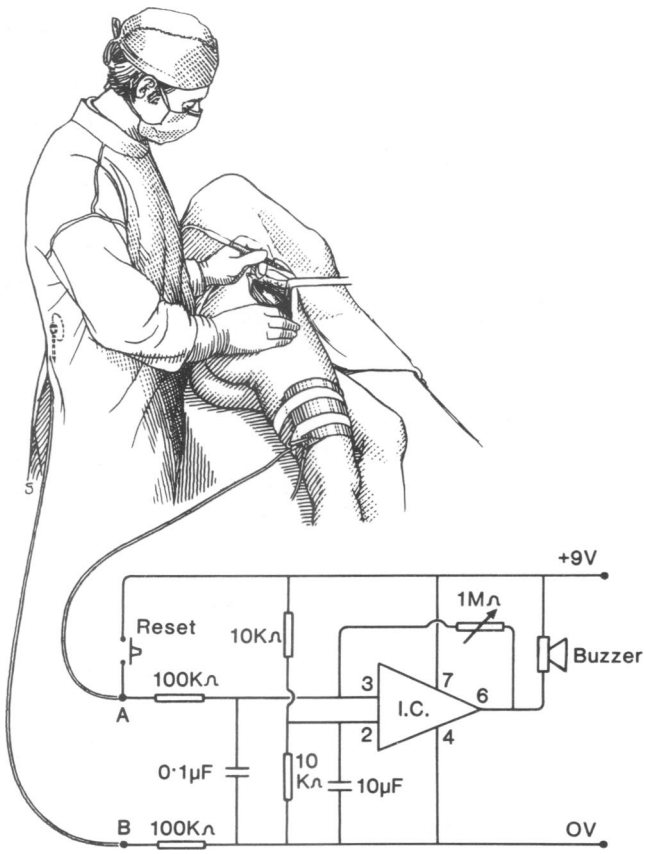

Figure 1. Diagram to show the circuit and its connections to the surgeon and patient. The integrated circuit (IC) is type LM 307N, resistances are quoted in kΩ or MΩ and capacitance in μF.

Table I. Summary of cases in study

Total joint arthroplasty	18
Foot surgery	15
Fracture surgery	11
Arthroscopy	9
Hand surgery	8
Others	19
Total	80

dressing, the surgeon would remove his glove and touch the patient away from the operative field. The alarm should sound to confirm the integrity of the circuit. The gloves used were also taken, filled with water and examined for leaks that may have been missed by the device.

Results

The mean duration of operation was 1 h 3 min and single gloves only were worn in 60 cases. The surgeon was double gloved in 20 cases.

Glove puncture occurred on 20 occasions in 80 operations (25%). On nine occasions the puncture involved single gloves and on eight occasions both the inner and the outer gloves were punctured when the surgeon was double gloved. On only three occasions were the outer pair of a double gloves punctured alone. Thus, there was a total of 17 occasions on which glove puncture detected either visually or by inflation with water should have resulted in contact of the patient's body fluids with the surgeon (Table II). There was normally only one episode of glove puncture per operation, but two occurred in four operations, and three punctures in one operation.

The alarm sounded 47 times in 27 operations. On 16 occasions the alarm sounded in response to glove perforation. In a further 30 cases, the alarm appeared to be set off by contact of the patient's body fluids with the surgeon through wet gowns and drapes. In the final case there was no obvious explanation for the alarm sounding (Table III).

On one occasion the device missed a glove perforation when the operator was single gloved. This was on the cuff of the glove, and could have resulted from overstretching while donning. It is possible that this puncture never came into contact with the wound and was therefore not in fluid continuity with it (Table II).

Thus, the device detected significant contact between patients' body fluids and the surgeons due to glove puncture, with a false-positive rate of 2.1% and a false-negative rate of 5.9%.

It was not possible to estimate the false-negative rate for the device when detecting contact through wet gowns or drapes as an independent test for fluid leaks via this route was not performed.

Table II. Glove punctures detected by device

	Glove punctures detected by underwater test	*No. of these punctures detected by device*
Double gloved	3 outer gloves (inners intact)	—
	8 inner and outer gloves	8
Single gloved	9	8

Table III. Summary of alarms

	No. of alarms	*No. of cases where alarms occurred*
Alarm sounding due to glove puncture	16	10
Alarm sounding due to wet gown/drapes	30	16
Alarm sounding without explanation	1	1
Total	47	27

Discussion

The rate of glove punctures of 25% in our series is comparable with other studies (*2*). The device detected all punctures but one. On occasions, punctures which were not expected led to regloving which was followed by another puncture in the fresh gloves. In one case the surgeon regloved three times. Although the number of gloves used was increased, the time for which the surgeon's skin was exposed to potentially infective material was decreased.

The frequent sounding of the alarm in response to wet gowns and drapes was unexpected. Cotton gowns are inefficient bacteriological barriers when wet (*5*), and in those cases where the alarm detected wet gowns and drapes, it also demonstrated a relatively easy path of exchange of organisms between the patient and the surgeon. This may have put the surgeon at risk, and in addition may have represented a direct path between unsterile parts of the surgeon and the wound. I suggest that in the event of the alarm sounding and no glove perforation being detected, measures should be taken to improve the draping and gowning.

The alarm sounded only once without explanation and we suggest that this false-positive rate of 2.1% is acceptable.

Since the device produced an audible alarm, it was not possible formally to determine whether the surgeon had realised that his gloves were punctured or not. It was noteworthy that on several occasions the surgeon was unaware of the puncture.

While it is impossible to warn of imminent glove perforation, the device is able to reduce the length of time a surgeon may be exposed to hazardous body fluids. By using this device, and by maintaining high standards of care throughout surgery, the risks to surgeons can be minimised.

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Book review

Sclerotherapy: Treatment of Varicose and Telangiectatic Leg Veins by Mitchel P Goldman. 403 pages, illustrated. Mosby Year Book, St Louis. 1991. £105.00.
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This book has been produced with meticulous care by the author. It is well referenced and contains a comprehensive description of the management, surgical and non-surgical, for varicose veins and telangiectasia. It may be surprising to many surgeons that this book is written by a dermatologist but in Europe and in the United States the specialty of Phebology is more advanced than in the United Kingdom and comprises physicians and dermatologists more than surgeons. The text contains a careful review of the aetiology of varicose vein disease and of the investigations necessary to accurately describe incompetent perforator disease. There is a chapter on the operative surgery of varicose veins by John Bergan and a critical review of the use of pulse of laser and sclerotherapy for telangiectasia of the lower limbs. It sensibly includes a list of the equipment required for setting up a sclerotherapy clinic and there is a useful appendix containing examples of consent forms, patient questionnaires and patient brochures. This book is a useful reference for any medical staff involved in the management of varicose veins.

LINDA DE COSSART
Consultant Surgeon
Chester Royal Infirmary