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Surgical glove failure rate

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Summary

Surgical gloves were collected after day-time operations for a 4-week period. Glove punctures were located by inflating each glove with compressed air and immersing the inflated glove in water.

During the period of the study 681 surgical operations were performed. A total of 3790 gloves was collected, 334 gloves (8.8%) had perforations at the end of the surgical procedure. Defects occurred in one or more gloves in 32.0% of all operations.

Introduction

It is well known that surgical gloves develop punctures during surgical procedures but the current frequency and extent of glove perforations is not generally known. Glove punctures can be related to defects of glove manufacture or to damage to the glove by surgical instruments or bone during an operation.

The surgical rubber glove was introduced as a method of protecting the hands of operating staff and it was only later established that surgical gloves were of benefit to the patient in reducing infection. However, the entire barrier effect is lost if even miniscule holes develop in the gloves *(1)*.

The rate of glove failure during surgery is of considerable relevance to Hepatitis B Virus and Human Immunodeficiency Virus (HIV) infection to surgeons, operating room nurses and to their patients.

The aim of the survey described in this paper was to establish the rate of break of surgical gloves currently used in North Tees General Hospital operating theatres.

Methods

TYPES OF GLOVES

Three types of surgical gloves are currently used in North Tees operating theatres. These are the Regent Dispo® Standard Gloves (powdered), Regent Biogel® Gloves (non-powdered) and Puritee® gloves. Puritee gloves were worn during the period of the study by one surgeon and two nurses who had developed allergies to the other gloves.

COLLECTION OF GLOVES

Surgical gloves were collected after day-time operations on weekdays for a 4-week period. Any known infected cases where there could be some risk to personnel in subjecting the gloves to testing were excluded from the study.

At the end of each operation the gloves worn by the surgeons and nurses were collected separately and placed in a solution of sodium hypochlorite. The testing of the gloves was carried out each evening when the majority of operations for each day had been completed.

METHOD OF TESTING

Glove punctures were located using the following method. The cuff area of the glove was stretched and examined visually. Each glove was then inflated to about 102 mm (4″) diameter using compressed air (at approximately 10 lb/in^2). The glove was sealed by gripping the cuff tightly and the inflated glove immediately immersed in water. While under water the glove was examined for any stream of bubbles which would indicate the presence of a hole.

A control sample of Biogel and Dispo gloves was tested. These were taken weekly from the normal supplies of surgical gloves in each theatre.

DATA ANALYSIS

The data analysis was carried out using a non-parametric analysis of variance by ranks technique from a programme developed by Patrick Royston 'SPP—A Statistics Package for Personal Computers' (Release 5.2) and further analysed by Scheffe Post-Hoc Pairwise Comparison.

In essence, the analysis investigated trends in the incidence of defective gloves within operation categories with common themes—for example, the incidence of

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defective gloves in all minor operations, the incidences being categorised by operation specialty.

Since glove use was subject to a wide range of variables (length of operation, operation class, specialty and so on), the act of grouping the data into categories for analysis (after the operation study was completed) probably led to some confounding of the data. This is exemplified in the glove-type data where assessing the gloves by type for comparison of puncture rates obscures the fact that one glove type was used preferentially in major operations. Major operations, being longer and more involved than minor or intermediate operations, had higher glove puncture rates irrespective of the glove type used.

Results

During the study period 681 surgical operations were performed, gloves were not used in 13 operations and the gloves were not collected for testing after a further five operations. A total of 3790 gloves was collected and tested from 663 operations, this included 2633 Dispo gloves, 1005 Biogel gloves, 150 Puritee gloves and 2 gloves for which the glove type was not specified. (Odd numbers are accounted for because if a glove failed and was replaced during an operation it was included in the count). It was found that 8.8% of gloves had perforations at the end of the surgical procedure.

The operations included in the study were classified as minor, intermediate or major. The classification was based on equipment used, the number of theatre staff involved and the length of operation. Of the gloves used in minor operations 105 (5.7%), 102 (9.3%) gloves used in intermediate operations and 127 (14.9%) gloves used in major operations were defective. In 218 operations (32.0%) defects occurred in one or more gloves.

Table I shows that there were no statistically significant differences between the puncture rates for the five specialties in both minor and major operations. The high puncture rate (31.3%) for major operations in urology was not statistically significant due to the small sample size. In the intermediate operation class, general surgery showed a higher puncture rate than the other specialties.

When the incidence of glove failures was compared for the three types of gloves it was found that the incidence of defective Biogel gloves was higher than for Dispo and Puritee gloves. Given that the incidence of glove failures increases progressively with operation classification and the major difference in distribution of glove types between these classifications (ie 40% of the operations in which Biogel gloves were used were classified as major operations in comparison with 7.8% for Dispo and 9.5% for Puritee), it would not seem appropriate to attach any significance to comparisons made on the basis of the overall failure rates according to glove type.

The puncture rates for the different glove types within the minor and major operation classifications are broadly similar within each class (Table II); in fact no statistically significant differences are evident. In the case of intermediate operations the puncture rate for Dispo is less than for either Biogel or Puritee, this difference being statistically significant.

The incidence of defective gloves for the surgeons (9.2%) was higher than for the nurses (8.1%). Table III shows that when the incidence of defective gloves is classified by user for both minor and major operations the differences between the various puncture rates within each class are small and in no case statistically significant. The only statistically significant difference to show up is for intermediate operations where the incidence of punctures for surgeons' right-hand gloves was less than the surgeons' left and nurses' left-hand gloves. Two of the surgeons and two of the nurses involved in the study were left-handed.

It was found that 176 (50.1%) of the holes occurred in

TABLE I *Incidence of defective gloves classified by specialty and operation class*

	Number of gloves: Number of defective gloves				*Incidence of defective gloves (%)*			
Operation class	*All classes*	*Minor*	*Inter*	*Major*	*All classes*	*Minor*	*Inter*	*Major*
Operation specialty								
Oral surgery	177:10	44: 2	113: 8	0: 0	5.7	4.5	6.0	—
Urology	348:19	244: 9	88: 5	16: 5	5.5	3.7	5.7	31.3
Orthopaedics	909:82	404:19	243:21	262:42	9.0	4.7	8.6	16.0
Gynaecology	1013:72	609:31	113: 4	291:37	7.1	5.1	3.5	12.7
General surgery	1351:151	535:44	535:64	285:43	11.2	8.2	12.0	15.1

One operation was carried out by two surgeons from different specialties. The gloves from this operation were therefore included in both specialties.

Statistical analysis of data:

Significant relationships ($P < 0.05$) between operation specialties:

Minor operations	No differences between specialties
Intermediate operations	Incidence of defective gloves higher in general surgery than in the other four specialties
Major operations	No differences between specialties

Significant relationships ($P < 0.05$) between operation classes:

Oral surgery	No differences between classes.
Urology	Incidence of defective gloves, Major > Inter = Minor
Orthopaedics	Incidence of defective gloves, Major > Inter > Minor
Gynaecology	Incidence of defective gloves, Major > Inter > Minor
General surgery	Incidence of defective gloves, Major = Inter > Minor

TABLE II *Incidence of defective gloves classified by glove type and operation class*

	Number of gloves: Number of defective gloves				*Incidence of defective gloves (%)*			
Operation class	*All classes*	*Minor*	*Inter*	*Major*	*All classes*	*Minor*	*Inter*	*Major*
Glove type								
All gloves	3790:334	1836:105	1100:102	854:127	8.8	5.7	9.3	14.9
Dispo	2633:194	1553: 87	742: 56	338: 51	7.4	5.6	7.5	15.1
Biogel	1005:126	197: 14	308: 39	500: 73	12.5	7.1	12.7	14.6
Puritee	150: 13	84: 3	50: 7	16: 3	8.7	3.6	14.0	18.8
Undefined*	2: 1	2: 1	—: —	—: —				

* Glove type not specified in one operation

Statistical analysis of data:

Significant relationships ($P < 0.05$) between glove types:

Minor operations	No differences between glove types
Intermediate operations	Incidence of defective gloves higher in Biogel and Puritee than in Dispo
Major operations	No differences between glove types

Significant relationships ($P < 0.05$) between operation classes:

Dispo gloves	Incidence of defective gloves, Major > Inter > Minor
Biogel gloves	Incidence of defective gloves, Major > Minor
Puritee gloves	Incidence of defective gloves, Major = Inter > Minor

TABLE III *Incidence of defective gloves classified by user and operation class*

	Number of gloves: Number of defective gloves				*Incidence of defective gloves (%)*			
Operation class	*All classes*	*Minor*	*Inter*	*Major*	*All classes*	*Minor*	*Inter*	*Major*
User/hand								
Surgeon/left	1280:137	585:40	371:42	324:55	10.7	6.8	11.3	17.0
Surgeon/right	1271: 97	582:32	369:25	320:40	7.6	5.5	6.8	12.5
Nurse/left	619: 58	335:20	181:22	103:16	9.4	6.0	12.2	15.5
Nurse/right	620: 42	334:13	179:13	107:16	6.8	3.9	7.3	15.0
Both/left	1899:195	920:60	552:64	427:71	10.3	6.5	11.6	16.6
Both/right	1891:139	916:45	548:38	427:56	7.4	4.9	6.9	13.1

Statistical analysis of data:

Significant relationships ($P < 0.05$) between users/hands:

Minor operations	No differences between users or hands
Intermediate operations	Incidence of defective gloves on surgeon's right less than on surgeon's left or nurse's left
Major operations	No differences between users or hands

Significant relationships ($P < 0.05$) between operation classes:

Surgeon/left	Incidence of defective gloves, Major > Inter > Minor
Surgeon/right	Incidence of defective gloves, Major > Inter = Minor
Nurse/left	Incidence of defective gloves, Major = Inter > Minor
Nurse/right	Incidence of defective gloves, Major > Minor
Both/left	Incidence of defective gloves, Major > Inter > Minor
Both/right	Incidence of defective gloves, Major > Inter > Minor

the finger, there was little difference in the distribution of holes in the crotch, palm and cuff. Thirteen gloves had more than one defect.

When the incidence of defective gloves was classified by operation duration it was found that the longer the operation duration the higher the incidence of defective gloves. In operations lasting less than 15 min 5.5% were defective, whereas for operations lasting more than 3 h the incidence was 27.1% (Table IV). The differences in incidence of defective gloves were significant between three broad groupings—operations lasting up to 1 h had fewer punctures than operations lasting between 1 and 2 h which, in turn, had fewer punctures than operations lasting more than 2 h.

Of the operations, 496 were classified as incisional, whereas 185 were non-incisional. A total of 598 gloves were used in non-incisional procedures, 31 (5.2%) were found to be defective at the end of the operation. If only incisional operations are considered in this study, it is found that 303 (9.5%) of the gloves used were defective at the end of the operation and defects occurred in one or more gloves in 193 (38.9%) of incisional operations.

TABLE IV *Incidence of defective gloves classified by operation duration*

Operation duration (min)	*Number of operations*	*Number of gloves used*	*Number of defective gloves*	*Incidence of defective gloves (%)*
Up to 15	235	863	47	5.5
16– 30	184	939	56	6.0
31– 60	138	847	65	7.7
61– 90	74	625	75	12.0
91–120	35	353	56	15.9
121–180	11	115	22	19.1
More than 3 h	4	48	13	27.1
Total	681	3790	334	8.8

Statistical analysis of data:
Significant relationships ($P < 0.05$) within operation duration data:
Incidence of defective gloves in operations of duration up to 60 min < 61–120 min < longer than 120 min

TESTING OF CONTROL

A sample of 524 unused gloves was tested as controls and 17 (3.2%) of these were found to be defective. The incidence of holes in the Biogel control gloves, 6 (4%), was higher than for the Dispo control gloves 11 (2.9%).

Discussion

In all instances the puncture rate increased progressively from minor through intermediate to major operations and in most cases the differences observed were statistically significant. The study has therefore shown that glove puncture rate increases with operation complexity and length.

In 218 (32.0%) operations defects occurred in one or more gloves, this is a lower rate than the study of 58 operations carried out at the Middlesex Hospital in 1984 *(2)*. In that study tears occurred in 35 (60%) of the operations studied.

The high number of operations in which perforations developed in the gloves gives cause for concern for the risk of cross-infection. A Collaborative Study (1980) *(3)* reported on eight patients who developed Hepatitis B associated with gynaecological surgery. It was thought that the infection was probably transmitted after accidental puncture of the surgeon's glove and skin.

In this series from North Tees, 8.8% of gloves had perforations at the end of the surgical procedure. Devenish and Miles in 1939 showed a puncture rate of 24.2% in 6585 gloves *(4)*; more recent studies have shown a higher rate of glove puncture, Furuhashi and Miyamae *(5)* report that in 14.8% of gloves used pinholes appeared, at Northwick Park Hospital *(6)* a small study showed that 15 (11.5%) of gloves used in one theatre were defective. In contrast a study of ophthalmic surgery *(7)* in Sendai, Japan in 1984 showed 3.8% of gloves had perforations at the end of the procedure.

These results using a very sensitive test for glove puncture demonstrate a lower rate of glove failure than many previous researchers have demonstrated. Nonetheless a failure rate of 8.8% does give cause for concern; gloves are widely believed to protect operating room personnel from infection and to protect patients from iatrogenic infection. This argument cannot be sustained. Operating room personnel will, inevitably, become infected via glove punctures; immunisation against Hepatitis B will protect nurses and doctors against one virus but what precautions can be taken against HIV infection? Would preoperative screening of patients encourage surgeons and nurses to take more care to avoid glove breakage when operating on HIV positive patients?

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