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Glove punctures in orthopaedic surgery

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Abstract From February 2001 to May 2001, 792 latex gloves used in 100 operations from three orthopaedic subspecialties (paediatrics, hand and spine) were tested for puncture by a water infusion test. Sixty-nine gloves from 45 operations were punctured, giving an overall glove perforation rate of 8.7% (69/792) and an operative perforation rate of 45% (45/100). The hand operations had the lowest operative perforation rate (19.4%) while the spine operations had the highest (63.6%). The glove perforation rate increased in bony procedures (60% versus 22.5%), in procedures with major instrumentation (66% versus 18%) and in more lengthy procedures. The thumbs and the left index finger had more punctures than other parts. In addition, the glove perforation rate for single gloving was 9.6% (53/552) while that for the inner glove of double gloving was 0.8% (1/120). Based on these findings, we would like to recommend double gloving and regular glove changing in these high-risk surgeries.

Résumé De février 2001 à mai 2001, 792 gants en latex, utilisés dans 100 opérations de trois “ sous spécialités ” orthopédiques (Pédiatrie, Main et Colonne vertébrale), ont été testé par une épreuve d’infusion de l’eau. Soixante-neuf gants de 45 opérations étaient perforés, en donnant un taux de la perforation global du gant de 8.7% (69/792), et un taux de perforation pendant l’opération de 45% (45/100). Les opérations de Main avaient le plus bas taux de perforation en opération (19.4%), pendant que les opérations de la Colonne vertébrale avaient le plus haut (63.6%). Le taux de la perforation des gants augment dans les procédures osseuses (60% contre 22.5%), dans les procédures avec instrumentation majeure (66% contre 18%), et dans les

plus longues procédures. Les pouces et l’index gauche avaient plus de perforations que d’autres parties de la main. De plus, le taux de la perforation du gant en cas de gant unique était de 9.6% (53/552) tandis que pour le gant intérieur en cas de double gantage ce taux était de 0.8% (1/120). Basé sur ces conclusions, nous recommandons des doubles gants et un changement régulier du gant dans ces chirurgies à haut risque.

Introduction

Glove failure during surgical operations is a recognised pathway through which surgeons and other operating-team members could be exposed to patients’ blood. While intact surgical gloves are impermeable to the HIV and hepatitis B virus, perforated gloves are not [2]. It has been shown that with adequate pre-operative hand preparation there is no risk to the patient from surgical-glove perforation [3]. However, the operating-team members are at risk to transmission of diseases from patients.

With a reported glove puncture rate of between 8 and 50% [3, 4, 10] and a 5% seropositivity of HIV amongst emergency room patients [6], it is important to identify factors causing glove puncture with the aim of finding a better solution to the problem.

A number of studies have shown that glove perforation is more common in orthopaedic operations than in any other surgical specialties [8, 12]. The reasons given for this high occurrence include needle injury; sharp, bony fragments and the use of sharp and complex instrumentations. Virtually all these studies were on trauma cases [4, 8, 9, 10]. The paucity of literature on other orthopaedic subspecialties prompted the authors to study the pattern of glove puncture in three orthopaedic subspecialties, namely hand, paediatric and spine.

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Materials and method

From February to May 2001, gloves used in the operating theatre of Duchess of Kent Children's Hospital for elective procedures lasting for more than 30 min were examined for perforation. A total of 792 latex gloves (Gammex-Ansell and Profeel) in 100 operations were tested by the water infusion method after each operation by a single observer [11]. Seventy-five new gloves were similarly tested for leakage and found without perforation. The operating team members from these 100 operations consisted of 100 chief surgeons, 132 assistants and 104 scrub nurses. Single pairs of gloves were used by 276 members while the remaining 60 members used double pairs of gloves. Personal preference determined single or double gloving.

The following information was documented soon after the completion of the procedures: nature of the surgery (bony or soft tissue), duration, whether instrumentation was used or not, single or double gloving, site of the puncture and awareness of the puncture during the operation. All surgeons, assistants and scrub nurses were right handed. Statistical analyses included the student *t* test, the chi square test and the one-way ANOVA.

Results

Sixty-nine punctures from 45 operations were identified in 792 gloves after 100 elective paediatric, spine and hand surgeries. This gives an overall glove perforation rate of 8.7% (69/792) and an overall operative perforation rate of 45% (45/100). Surgeons and nurses had higher glove perforation rates of 10.1% and 11.7% respectively, while assistants' glove perforation rate was only 5.7%. The operative perforation rate showed a similar trend (Table 1). For the single gloving group, 53 out of 552 gloves (9.6%) were found punctured. For the double gloving group, only one of 120 inner gloves (0.8%) was punctured. This was found to be statistically significant ($p < 0.001$).

Of the 69 glove punctures, 51 (73.9%) were not noticed by the operative team members and were only detected by the water infusion test after the operation. The most common sites included the thumbs and the left index finger. Left-hand gloves had more punctures than right-hand ones (Table 2). There were two wound infections encountered. There was a gradual increase in the incidence of glove puncture as the duration of surgery increased. Eight out of 26 (30.8%) operations that lasted 30–60 min had glove puncture while 12 of 33 (36.4%) operations lasting 61–120 min had glove puncture. The operative perforation rates were 47.4% (9/19) if the

Table 2 Puncture sites

	Right	Left	Total
Thumb	15	15	30
Index fingers	1	17	18
Other fingers	1	9	10
Palm	7	4	11
Total	24	45	69

Table 3 Glove perforation rates versus grade of instrumentation

	Instrumentation		
	Nil (<i>n</i> =33)	Minor (<i>n</i> =34)	Major (<i>n</i> =33)
Overall	3.5% (7/200)	8.6% (20/232)	11.7% (42/360)
Surgeon	3.9% (3/76)	8.8% (7/80)	17.1% (14/82)
Assistants	0.0% (0/56)	3.8% (3/80)	8.2% (16/196)
Scrub nurses	5.9% (4/68)	13.9% (10/72)	17.6% (12/82)

operations lasted for 121–180 min and 72.7% (16/22) if operations lasted for more than 180 min.

Overall glove perforation rates were 10.9% (59/542) in bony procedures and 4.0% (10/250) in soft-tissue procedures ($p < 0.001$). Surgeons had glove perforation rates of 2.2% (2/90) in soft-tissue procedures and 14.9% (22/148) in bony procedures ($p < 0.001$). Assistants had no glove perforation (0/78) in soft-tissue procedures, but 7.5% (19/254) in bony procedures ($p < 0.001$). For the scrub nurses, the glove perforation rates in soft-tissue and bony procedures were 9.8% (8/82) and 12.9% (18/140) respectively ($p > 0.25$). The operative perforation rate was also higher in bony procedures (60%, 36/60) than in soft-tissue procedures (22.5%, 9/40) ($p < 0.001$). The mean operative time for bony procedures was 161.3 (range 40–450) min while that for soft-tissue operations was 96.4 (range 30–300) min ($p < 0.05$).

There were 33 operations without the use of instrumentation, while 34 operations involved the use of minor instrumentation and 33 procedures required major instrumentation. The glove perforation rate increased ($p < 0.05$) when instrumentation of increasing complexity was used (Table 3). Again, the surgeon and the assistant groups reviewed the same trend. In the scrub-nurse group, once instrumentation was used, whether minor or major, the glove perforation rates increased sharply. The operative perforation rate also increased with instrumentation (no instrumentation: 18% (6/33), minor instrumentation: 50%

Table 1 Glove perforation rates and operative perforation rates

Team members	Number of members	Number of gloves used	Number of gloves punctured	Glove perforation Rate ¹	Operative perforation Rate ²
All	336	792	69	8.7	45
Surgeons	100	238	24	10.1	23
Assistants	132	332	19	5.7	16
Scrub nurses	104	222	26	11.7	23

¹ Glove perforation rate = percentage of used gloves that was punctured

² Operative perforation rate = operations with punctured gloves in percentage of all operations

Table 4 Glove perforation rates in high-risk situations

Situation	Single gloving	Inner glove in double gloving
Duration >3 h ($p<0.01$)	12.5% (16/128)	1.4% (1/74)
Spine operation ($p<0.01$)	16.7% (22/132)	1.4% (1/70)
Bony procedures ($p<0.001$)	13.8% (46/334)	1.0% (1/102)
Major instrumentation ($p<0.001$)	16.8% (32/190)	1.2% (1/84)

(17/34), major instrumentation: 66% (22/33), $p<0.05$). The mean operative times for operations with no instrumentation, minor instrumentation and major instrumentation were 83.2 (range 35–165) min, 102.6 (range 30–300) min, and 221.1 (range 45–450) min respectively ($p<0.05$). There were 22 spine, 31 hand and 47 paediatric procedures. The mean operative time for spine operations was 260.5 (range 55–450) min while that for the hand and paediatric operations were 86.6 (range 30–165) min and 108.8 (range 35–300) min respectively ($p<0.05$). The operative perforation rates were 19% (6/31) in hand operations, 53% (25/47) in paediatric operations and 63% (14/22) in spine operations ($p<0.05$).

As mentioned before, spine operations, bony procedures, operations with major instrumentation and lengthy procedures carry higher risk of glove puncture. In these high-risk situations, perforation rates of the inner glove in the double-gloving group are lower than perforation rates in the single-gloving group (Table 4).

Discussion

As far as the authors are aware, there is no literature addressing the incidence of medical personnel contracting blood-borne diseases resulting from glove puncture. In spite of that, glove puncture remains a major concern to health personnel in the operating theatre, as it is a definite theoretical pathway of transmitting blood-borne diseases. In this study, the 8.7% overall glove perforation rate was within the often-quoted range [3, 4, 10]. However, the operative perforation rate was 45%, that is, almost half of the operations had glove punctures, and the operative team members were at significant risk of exposure to patients' body fluid. It is also alarming to find that the glove perforation and operative perforation rates for scrub nurses were as high as those for surgeons. This is probably due to the significant handling of instruments by nurses in instrumented procedures. Furthermore, about three quarters of the glove punctures were not recognised during the operation.

There is a consensus in the literature that the left (non-dominant) hand is more affected than the right, and the index and the thumb more than the other fingers in glove failure [1, 7]. The findings in this study of 65% left hand and 70% index and thumb involvement support the views of others that the dominant hand is used for more elegant manoeuvres during operation while the left is used for coarse and awkward manipulations [1]. This study also supports the finding that the longer the duration of surgery, the higher would be the rate of glove failure.

Increased permeability of gloves, human fatigue, and more importantly, the nature of operations and use of instrumentation, are important implicating factors.

As reported previously [8, 9], the nature of the surgery also influences the incidence of glove failure. Bony procedures, either because of the hard and sharp nature of the bone or higher percentage of instrumentation, tend to be associated with a higher glove failure than soft-tissue procedures. Moreover, the mean operative time for bony procedures is longer than that of soft-tissue operations, which may also be a contributing factor for the higher incidence of glove failure. The use of instrumentation also increases the risk of glove failure. This may be explained by the fact that some of the instruments, e.g. screws, drills, wires and metal cutters, have sharp edges or points. Careless handling may cause glove punctures and lacerations. Again, the mean operative time is longer once instrumentation is required.

Glove failure is more common in spine operations than in hand and paediatric operations. As reported before, the mean operative time of spine surgery is much longer than that of the other two sub-specialties. Moreover, spine surgery more often involves the use of major instrumentation. This is especially so in this hospital, which is a major centre in scoliosis surgery that requires the use of major and complex instrumentation.

In summary, the risk factors for glove puncture include long operative time, bony procedures, procedures with instrumentation and spine surgery. However, it should be pointed out that all these factors are inter-related. In spite of all the research on the subject, there is still no absolute measure that guards against glove failure. Herscovici et al. [5] have shown in their clinical and laboratory studies that some cloth gloves are much more resistant to perforation by slicing or chopping than latex gloves. However, he also reported that the surgeons found these cloth gloves more uncomfortable to wear. Hence, surgeons may not like to use these cloth gloves, though they are more puncture resistant.

The incidence of inner-glove puncture in the double-gloving group is 0.8%. This is significantly lower when compared with the 9.6% glove failure found in single gloving. This finding is similar to the observation of Macleod [10] who showed that double gloving reduces the incidence of glove failure and thus diminishes the exposure of the operating-team members to patients' blood. Even in high-risk situations, as shown in Table 4, double gloving gave better protection to the operative-team members. The routine use of double gloving in operations will invariably increase the medical expenses.

The cost of a pair of surgical gloves locally is about a quarter of one US dollar, which is nothing compared to the overall cost of an operation. Although there is still no evidence to show that double gloving reduces the incidence of the medical personnel contracting blood-borne diseases, the authors still believe that the increase in expenses will be well compensated if double gloving can prevent even a few cases of blood-borne diseases, which require expensive treatment. Also, this will give the operation-team members ease of mind during operations. A reasonable compromise is to practice double gloving only in high-risk surgeries, as mentioned before, and when patients are known carriers of blood-borne diseases.

Glove puncture is common in orthopaedic operations. Most of them are un-recognised during surgery. Risk factors include long operative time, bony procedures, instrumentation and spine surgery. Chief surgeons and scrub nurses are at higher risks. Double gloving gives better protection and is more practical and comfortable to the operative personnel.

The authors would like to recommend double gloving, especially in "high-risk" operations, and changing the gloves every 2 h in prolonged operations.

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