Glove perforation rate in open lung surgery

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Abstract

Objective: In open lung surgery the surgical access is encircled by the ribs, which should result in a high glove perforation rate compared with other surgical specialties. Methods: Prospectively the surgeon, first and second assistant and the scrub nurse wore double standard latex gloves during 100 thoracotomies. Parameters recorded were: procedure performed, number of perforations, localization of perforation, the seniority of the surgeon, manoeuvre performed at the moment of perforation, immediate cause of perforation, operation time, performance of rib resection during thoracotomy and time of occurrence of the first three perforations. Results: One thousand, six hundred and seventy-three gloves (902 outer, 771 inner) were tested. In 78 operations perforations occurred. There were 150 outer glove perforations (8.9%, 0–8, mean 1.23), 19 inner glove perforations (1.13%, 0–2, mean 0.19). Cutaneous blood exposure was prevented in 78% of all operations and in 87% of all perforations. The perforation rate for the surgeon, the scrub nurse, the first and the second assistant were 61.2, 40.4, 9.7 and 3.1% of all operations, respectively. Rib resection and a duration of more than 2 h resulted in a significant rise of glove perforation rate ($P < 0.05$). The personal experience of the surgeon and the type of operation did not correlate with glove perforation. The immediate cause leading to perforation was named in only 17 cases (13.7%) and comprised contact with bone (seven), a needle stitch (seven) and a production flaw (three). Leaks were localized mostly on the first finger (18%), second finger, (39%) palm and dorsum of the hand (16%). The average occurrence of all first perforations was 38.7 min (range 3–190) after the beginning of surgery, the second after 63.2 min (range 10–195). Fifty-four first perforations (50.5%) were found during the first 30 min of the operation. Conclusions: The reported perforation rate of 78% lies in the highest range of reported perforation rates in different surgical specialties. Double gloving effectively prevented cutaneous blood exposure and thus should become a routine for the thoracic surgeon to prevent transmission of infectious diseases from the patient to the surgeon. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Glove perforation; Thoracic surgery; Lung surgery

1. Introduction

Glove perforation during surgery is a well-known problem. The perforation rate can range from 13 to 43% and results in an enhanced risk of infection with HIV, HBV and other blood-borne diseases for the surgical team. In contrast to many other specialists, the thoracic surgeon has to work through an opening in a rigid cage. The surgical access is encircled by the ribs, which, due to their bony structure, are prone to perforate surgical gloves. To date, only in cardiac surgery, as a speciality of thoracic surgery has glove perforation been investigated. The perforation rate was 49% for the surgeon, 43% for the assistant and 31% for the scrub nurse [1]. Glove perforation in lung surgery has not yet been investigated; however, a similarly high rate of perforation is to be expected.

2. Materials and methods

In a prospective study conducted between July 1996 and December 1996, the surgeon, first and second assistant and the scrub nurse wore a double-gloving system of latex gloves for 100 thoracotomies. The outer gloves were normal Biogel Super-Sensitive latex gloves, the inner gloves did not correlate with glove perforation.
results in an inflow of fluid between the two pairs of gloves. The wet area of the inner glove then appears as a bright green spot under the perforation area of the outer glove, which can be easily noticed by the wearer. Once a perforation occurs and is recognized, the outer glove is removed and the inner glove examined for perforations. If the inner glove has remained intact, only the outer glove needs to be changed. If both gloves become perforated a complete new double glove set is donned. The following parameters were recorded in this study: type of procedure performed, number of perforations, localization of perforation, the seniority of the surgeon, which manoeuvre was being performed at the moment of perforation, the immediate cause of perforation, operation time (min), whether a rib resection was performed during thoractomy and time of occurrence of the first three perforations (min). Brown [7] demonstrated that if a Biogel glove showed a green spot, a puncture was verified by a reproducible water test in 100% without a false positive result. Therefore, we refrained from water testing in this study.

3. Statistical evaluation

All data were entered into a PC (Compaq PC, IBM compatible, Windows 98, Pentium) and evaluated by a statistical program (SPSS for Windows, version 6.1). The statistical method employed was cross-tabulation, calculating the Chi-square probabilities under the null hypothesis that all profession groups are underlying the same risk of glove perforation, and that experience of the surgeon, operation time, rib resection and the type of operation do not influence the rate of glove perforation. The applied level of significance was 0.05.

4. Results

A total of 1673 gloves (902 outer gloves, 771 inner gloves) was tested and 169 perforations found, an overall incidence of 10.1%. Due to impairment of sensation and dexterity as a result of double-gloving, the wearing of double gloves was refused by the surgeon and the first assistant in five. In 78 operations a glove perforation occurred. The risk for the first and second assistant was 9.7 and 3.1%, respectively. The perforation rates of inner and outer gloves are shown in Table 1.

A single glove perforation was detected in 41 operations, two perforations in 22, three in 10 and four to 10 perforations in five surgical procedures (Table 2). Operation time ranged from 30 to 265 min (mean 121.24, SD 46.75). A duration of more than 2 h resulted in a significant rise of glove perforation rate (P < 0.05). The personal experience of the surgeon did not correlate with glove perforation. At thoracotomy a rib was resected in 64 patients. Rib resection resulted in a higher perforation rate (P < 0.05). Due to the high number of different operations the statistical evaluation could not identify a special type of procedure as a risk factor for glove perforation.

The procedures performed at the time of glove perforation were identified in 59 perforations (47.6%). Cauterization was named in three cases, suturing in seven, incision in five, mechanical action in 12, use of scalpel, scissors or needles in eight and administration of instruments in 13. In 11 cases the gloves simply tore without any correlation with the named procedures. In only 17 cases (13.7%) could the cause leading to perforation be named. Contact with bone and a needle stitch caused perforations in seven cases each, and on three occasions a flaw in production was named.

Visual localization of leaks was possible in 112 cases and is shown in Table 3. The first perforation occurred with the surgeon’s gloves (n = 56) between 5 and 190 min (median 25), the second (n = 17) between 15 and 195 min (median 55), the third (n = 5) between 20 and 205 min (median 87). The nurse’s gloves perforated for the first time (n = 40) between 3 and 135 min (median 27.5) and for the second time (n = 5) between 10 to 92 min (median 69). The first perforation occurred with the first assistant’s gloves (n = 9) between 3 and 60 min (median 35), the second (n = 3) between 55 and 130 min (median 120).

The average incidence of all first perforations was 38.7 min (range 3–190) after the beginning of surgery, the second after 63.2 min (range 10–195). Fifty-four first perforations (50.5%) were found during the first 30 min of the operation.

4.1. Table 1

Glove perforation rates (the numbers in parenthesis indicate the number of perforations during operation and the mean number of perforations per operation)

<table>
<thead>
<tr>
<th></th>
<th>Outer</th>
<th>Inner and outer</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgeon</td>
<td>70 (0.8,-1.76)</td>
<td>13 (0.2,-0.13)</td>
<td>96</td>
</tr>
<tr>
<td>1st assistant</td>
<td>11 (0.2,-0.05)</td>
<td>2 (0.1,-0.02)</td>
<td>15</td>
</tr>
<tr>
<td>2nd assistant</td>
<td>2 (0.1,-0.03)</td>
<td>1 (0.1)</td>
<td>4</td>
</tr>
<tr>
<td>Scrub nurse</td>
<td>48 (0.3,-0.48)</td>
<td>3 (0.3,-0.03)</td>
<td>54</td>
</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>19</td>
<td>169</td>
</tr>
</tbody>
</table>
Glove perforation is a well-known problem for the surgeon and the scrub nurse. The seroconversion rates after percutaneous exposure to HIV are estimated as 0.3% and after exposure to HBV as 30% [2]. However, the infection risk to the patient due to glove perforation is negligible. Dodds et al. [3] demonstrated that the elimination of the surgeon’s transient skin flora as a result of current standard preoperative hand preparations remains the main factor for preventing iatrogenic sepsis. The recovery of the permanent skin flora (i.e. Staph. epiderm.) does not result in increased wound infection rates [3]. Therefore, the early recognition of glove perforation remains the prime defence mechanism for protection of the surgeon and the scrub nurse.

The rate of glove perforation has been extensively investigated in various surgical specialities. The reported overall perforation rates have been 21.5% in plastic surgery [4], 26% in orthopaedic surgery [5], 13.3% in obstetrical procedures [6], 12.7% in general surgery [3] and up to 48% in trauma surgery [7]. The thoracic surgeon faces a similar risk to the traumatic surgeon due to the presence of bony structures in the thoracic cage. In this context, our high perforation rate of 61% for the surgeon was to be expected. In this study no type of operation was associated with a higher perforation rate. In accordance with the literature, an operation time of more than 2 h also resulted in an enhanced perforation rate [4]. The seniority of the surgeon was not associated with a higher perforation rate, although this has been reported to be a significant risk factor in abdominal surgery and gynaecology [8,10]. Contact with bone and needle stitches were the most prominent causes in our study, a result also confirmed by the literature [7,9,11]. Rib resection creates a sharp bone margin which increases the perforation rate significantly. Fifty percent of all first perforations occurred within the first half hour of the operation, suggesting that thoracotomy represents a major risk for all members of the operating room staff.

The fact that in 35.5% of all perforations a hole was not visible, underlines the danger of an unrecognized small perforation. Only in 13.7% of all perforations could the definitive cause be identified, suggesting that in the remaining cases the perforation was simply not recognized at the time of occurrence – a very low rate compared with other investigators, who have reported a perforation detection rate of between 19% [16] and 38% [6,8].

5. Discussion

The risk to the scrub nurse (40.4% of all operations) was unexpectedly high. Other studies have found a risk of between 23% [10,11] and 36% [5]. Our high rate of glove perforations where the scrub nurse is concerned might be explained by a rather unusual practice intrinsic to our department: the standard thoracotomy instrumentation set contains a rather minimal amount of surgical instruments, which is augmented intraoperatively by individually sealed and sterilized instruments. As this seal consists of a double layer, the outer one is opened by the scrub nurse assistant, whereas the inner layer is opened by the scrub sister herself. This activity, in many cases, leads to excess stress of the outer glove, thereby rupturing it. When the nurse takes wet swabs from the sterile basin, the capillary indicator effect between the double gloving is instituted resulting in the leak becoming visible.

While the high incidence of perforations of the second finger (39%) lies in the range of the literature (45–58% [5–12]) the dominance of the dorsum of the hand and the wrist as a perforation site (16%) seems to be a characteristic of the thoracic surgeon, and is only matched by one study conducted in plastic surgery [4]. Again the frame of ribs encircling the surgical access can be regarded as the main cause for this occurrence. In our series, the number of perforations of the thumb was rather low when compared with the literature, which reports rates of between 20% [6] and 39% [12].

The inner glove prevented cutaneous blood exposure in 78% of all operations and in 87% of all perforations. The fact that no isolated inner glove perforation was found is in accordance with the literature [13]. However, others report a glove perforation rate before use of between 1.5% [14] and 3% [3].

It is estimated that 13% of operating room staff show skin damage, existing preoperatively, which significantly increases the risk of infection [9]. During the study, several members of the staff refused to use double gloving. The reasons given were reduction in sensation and inability to perform fine manipulative skills accurately. As double gloving was not a routine in our department before the study, we had no time to get used to it. However, the majority of the staff got familiar with double gloving very quickly. Whether

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**Table 2**

<table>
<thead>
<tr>
<th>Number of perforations</th>
<th>One perforation</th>
<th>Two perforations</th>
<th>Two perforations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgeon</td>
<td>41</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>1st assistant</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2nd assistant</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Scrub nurse</td>
<td>35</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

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**Table 3**

<table>
<thead>
<tr>
<th>Visual localization of leaks in 112 cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgeon</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>1st finger</td>
</tr>
<tr>
<td>2nd finger</td>
</tr>
<tr>
<td>3rd finger</td>
</tr>
<tr>
<td>4th finger</td>
</tr>
<tr>
<td>5th finger</td>
</tr>
<tr>
<td>Palm</td>
</tr>
<tr>
<td>Dorsum</td>
</tr>
<tr>
<td>Wrist</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
this period of adaptation to the use of two pairs of gloves results in a higher perforation rate is not known. It also remains unclear, whether the wearers of two pairs of gloves are more prone to accidental perforations as a result of impaired sensitivity. Unfortunately, the literature does not provide data which might clarify this problem. Up to 26% of surgeons remove their double gloves due to reduced sensitivity and dexterity [15] This represents the major problem of double gloving, and is still waiting to be solved. Until that happens, every surgeon must balance the improved security provided by a second barrier between himself and the patient, against possible discomfort resulting from perceived impairment of sensation and dexterity.

6. Conclusion

Double gloving represents an effective protection for the surgeon. The green colour of the indicator gloves allows early recognition of perforation and thus lessens the surgeon’s exposure time to a patient’s body fluid. Thoracic surgery is a speciality prone to glove perforation due to the proximity to the bony structure of the chest wall. The reported perforation rate of 78% lies within the highest range of reported perforation rates for different surgical specialties. Rib resection should be avoided whenever possible. The thoracotomy instrumentation set should include all instruments needed. A system requiring augmentation by vaccination, this is not yet possible with hepatitis C.

While the risk of hepatitis B infection can be overcome by vaccination, this is not yet possible with hepatitis C. False negative HIV tests occur in the window before seroconversion during early infection, making routine preoperative testing a questionable (and of course expensive) precaution. Even if infection is proven, the preoperative knowledge of the seropositivity of a transmissible disease does not result in a reduced perforation rate [17], suggesting that surgeons do not change their operation techniques although being aware of an increased transmission risk. Also, occasionally surgeons transmit diseases to their patients. Thus any effective preventive strategy should not be restricted to known carriers of infective diseases or special risk groups but applied to all patients undergoing surgery. Double gloving with a colour-change indicator system should become routine to prevent transmission of infectious diseases from the patient to the surgeon in open lung surgery.

References