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ORIGINAL ARTICLE

Cut-resistant protective gloves in pathology—effective and cost-effective

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Abstract Cutting injuries and needle-stitch injuries constitute a potentially fatal danger to both pathologists and autopsy personnel. We evaluated such injuries in a large German institute of pathology from 2002 to 2007 and analysed the effect of the introduction of cut-resistant gloves on the incidence of these injuries. In the observation period, 64 injuries (48 cutting injuries and 16 needle-stitch injuries) were noted in the injury report books. Most injuries were located at the non-dominant hand, preferentially at the index finger and the thumb. Around one fifths of the injuries were at the side of handedness. The average number of injuries per month was 1.22 for the 50months prior to the introduction of cut-resistant gloves, more than seven times higher than after their introduction (0.158; 19months; $p < 0.001$). Considering the medical and administrational costs of such injuries, cut-resistant protective gloves are an effective and cost-effective completion of personal occupational safety measures in surgical pathology and autopsy. We strongly recommend the use of such gloves, especially for autopsy personnel.

Keywords Cutting injury · Protective gloves · Cut-resistant · Pathology · Occupational safety

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Introduction

Besides histological diagnostics, conducting autopsies and preparing and dissecting surgical pathology specimen are the main tasks of surgical pathologists. Because precision is paramount for pathological workup of tissue, both former activities include the use of various extremely sharp blades and scalpels (Fig. 1a). Suturing bodies at autopsies further implicates the use of solid-core needles (Fig. 1a). Not surprisingly, the constant use of such instruments quite frequently leads to injuries. Cutting injuries and needle-stitch injuries could vary from harmless superficial wounds to deep lacerations.

An additional danger associated with the handling of fresh or partially fixed human tissue is the danger of transmission of blood-borne diseases. The possibility of disease transmission by autopsies was first recognised by the Austrian–Hungarian physician Ignaz Philipp Semmelweiss in the nineteenth century [4, 7]. Although many infectious diseases from Semmelweiss' times would probably be less fatal today, serious blood-borne disease like viral hepatitis B and C (HCV) or human immunodeficiency virus (HIV) remain a potentially fatal thread [3, 11]. The theoretical career risk for pathologists and autopsy assistants is definitely not negligible [17]. Moreover, several other infectious diseases were found transmittable at autopsies or by cutting/needle-stitch injuries [2, 5, 6, 8, 19, 25, 27].

In 1987, Steger analysed the life expectancy and causes of death of pathologists in Germany and found that their life expectancy was reduced in comparison to the normal population due to a rather high rate of occupational infections, accidents and suicides [22]. If unnatural causes of deaths and occupational infections were excluded, the life expectancy converged to that of the normal population [22]. Personal safety measures have strongly evolved over

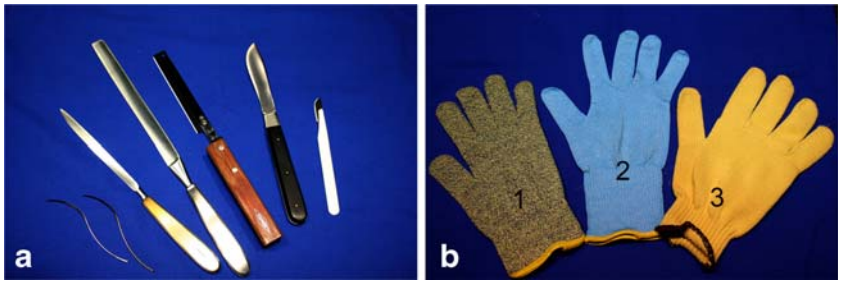

Fig. 1 **a** Selection of blades and needles used in the dissection and autopsy divisions. **b** Three different cut-resistant gloves (1: Vantage™ 2: proFood® Safe-Knit®; 3: GoldKnit™). The gloves differ in thickness, dexterity, elasticity and price

time (Fig. 2). The improvements made could mainly be contributed to a better understanding of the causes and origins of diseases.

In this study, we analysed cutting and needle-stitch injuries before and after the introduction of cut-resistant gloves as an additional routine safety measure for pathologists and autopsy assistants. Some laboratories have already used such *protective gloves* before. We hope that the results of this study will persuade more pathologists to introduce this easy, effective and cheap safety measure.

Materials and methods

Data collection

Our analysis was performed at the Institute of Pathology (Charité Campus Mitte (CCM) and Campus Virchow Klinikum (CVK)) of the Charité Universitätsmedizin Berlin. This large institution is the service provider of pathologic diagnostics for two university campuses of the Charité and several peripheral hospitals and physicians. For our analysis, we reviewed the injury report books (IRB) from the central preparation and dissection laboratory (CPDL) for surgical specimen and from two autopsy divisions (CCM–CVK). We included all cutting and needle-stitch injuries from January 2002 until September 2007. Cutting injuries of medical laboratory assistants with microtome blades (different division) and cutting injuries aside the hands were excluded.

Year, type and side of injury were noted. Handedness and protective measures used at the time of injury were assessed from the IRB and personnel interviews if possible.

In addition, we assessed the number of autopsies for each year and the annual number of surgical specimen processed. Information about costs for the treatment of needle-stitch and cutting injuries were obtained from the compulsory accident insurance companies in Berlin, Munich (Bavaria) and Düsseldorf (North Rhine–Westphalia (NRW)).

Change of occupational safety measures

Standard safety measures for autopsies and dissection of surgical specimen included cotton protective clothing, protective shoes, plastic skirts and single or double layers of latex or vinyl gloves. Furthermore, surgical masks and protective eyewear were used in the autopsy divisions.

Starting February 2006 cut-resistant gloves (different types (Fig. 1b), Ansell Healthcare Europe NV, Brussels, Belgium) were introduced at both autopsy divisions for all physicians, autopsy assistants and students working with blades and needles. From April till the beginning of July, extra-thin cut-resistant gloves (Fig. 1b, proFood® Safe-Knit® and Vantage™, Ansell) and protective eyewear (Uvex Arbeitsschutz GmbH, Fürth, Germany) were introduced at the central preparation and dissection laboratory. Additionally, in all three divisions, highly fluid resistant respirators (Health Care Respirator 1873V FFP3 with valve, 3M St. Paul, MN, USA) of the highest protection level (filter face piece protection level 3 = FFP3) against airborne particles (e.g. fungal spores) aerosols (e.g. tuberculosis [9, 10, 18, 24])

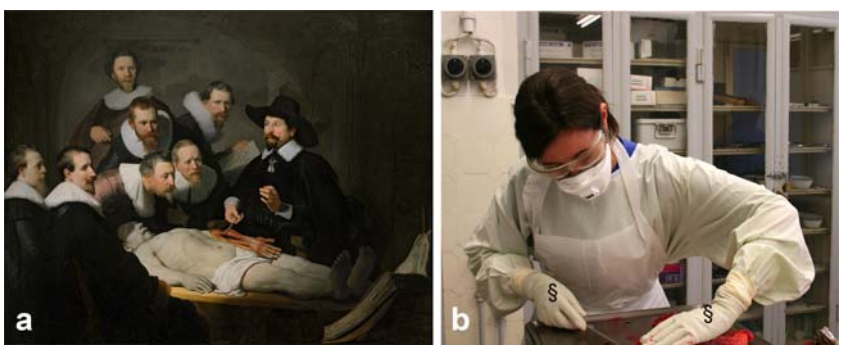

Fig. 2 Personal safety measures at different times: **a** The anatomy lesson of Dr. Tulp (Rembrandt, Royal Picture Gallery Mauritshuis, The Hague, the Netherlands). **b** Pathology resident at the Charité Universitätsmedizin Berlin with the new standard personal safety measures (protective clothing, protective eyewear, FFP3 respirator, doubled-latex gloves and cut-resistant gloves (§))

and viruses (e.g. HIV, HCV, H5N1 flu) replaced the conventional surgical mask as standard protection.

Statistics

For statistical analysis, we used SPSS 14.0 (SPSS Inc. Chicago, IL, USA). To asses differences in incidence rates, number of autopsies and number of surgical specimen, the Mann–Whitney *U* test and the Kruskal–Wallis test were applied. Correlation analyses were performed applying Spearman's rank order correlation. *P*-values < 0.05 were considered significant.

Results

In the observation period, 48 cutting injuries and 16 needle-stitch injuries were reported. Most injuries occurred in the autopsy divisions, where pathologists reported three cutting injuries and autopsy personnel reported the remaining 33 cutting injuries as well as all needle-stitch injuries. The remaining 12 cutting injuries occurred to pathologists in the dissection division. Typical activities associated with the occurrence of injuries were organ exenteration, suturing the body at the end of the autopsy, cutting and slicing surgical specimen or changing blades.

Detailed characterisation of the injuries is provided in Table 1. Thirty-six of the injuries (56%) affected the non-dominant hand, while the dominant hand was injured in 20% (13 cases). For the remaining cases, either the handedness or the hand injured was unknown. Concerning the exact location, the index finger was most often affected (20×) closely followed by the thumb (15×) and further behind the middle finger (7×), little finger (3×) and the ring finger (2×).

Sixty-one of the injuries happened between January 2002 and February 2006 (before the introduction of cut-resistant gloves in the specific divisions), which results in an average of 1.22 injuries per month. The remaining three injuries (two needle stitches and one cutting injury) took place 19months after introduction of the new safety concept, resulting in an average of 0.158 injuries per month. This difference in the incidence rate was statistically highly significant (Mann–Whitney *U* test: $p < 0.001$, Fig. 3). If July 2006 but not February (completed introduction in CPDL) was used as the cutoff, the values changed to 1.15 injuries per month before and 0.13 injuries per months after the introduction of the gloves ($p = 0.001$). Interestingly, the cutting injury and one of the needle-stitch injuries reported after February 2006 occurred to persons who did not wear cut-resistant gloves at this time. One needle-stitch injury happened although cut-resistant gloves were worn.

The average number of surgical specimen investigated and autopsies performed varied around 41,500 (range 39,000–44,000) for the former procedure and around 470 (range 440–510) per year for the latter procedure. The differences in the number of surgical specimen diagnosed and autopsies performed were not statistically significant between years ($p = 0.416$ for both autopsies and surgical specimen), indicating that changes in the incidence of injuries were not due to differences in yearly work load. Furthermore, there was no correlation between the number of injuries and that of autopsies or surgical specimen ($p = 0.468$ and $p = 0.623$). Although a normal fluctuation of employees took place in all three included divisions, the number of employees in the respective division at a given time remained constant (data not shown). To test for a general trend of not reporting injuries in certain times, we compared the frequencies of all other injuries in the IRB for the respective years (2002, 2; 2003, 11, 2004, 5; 2005, 13; 2006, 12; 2007, 7). To improve intra- and inter-institutional comparability, we related cutting and needle-stitch injuries to the number of autopsies and surgical specimens. Per 100 autopsies, 2.5 injuries occurred before and 0.4 after the introduction of cut-resistant gloves. The equivalent numbers for 10,000 surgical specimens were 0.7 and 0.0.

Only ten of the cutting and needle-stitch injuries noted were reported to the accident insurance company and

Table 1 Characteristics of cutting injuries (CI) and needle-stitch injuries (NS) for the respective years (2007: January–September)

Characteristic	2002		2003		2004		2005		2006		2007	
Type of injury	CI	NS	CI	NS	CI	NS	CI	NS	CI	NS	CI	NS
Number of injuries	12	6	19	3	8	3	7	2	2	1	0	1
Right hand	3		8	3	1			1				
Left hand	6	6	11		6	3	6	1	2	1		1
Unknown hand	3				1		1					
At side of handedness	2		6	3	1	1						
At contralateral hand	5	5	12		4	1	4	1	2	1		1
Unknown handedness	5	1	1		3	1	3	1				
Cut-resistant gloves used										1		
Latex–vinyl gloves only	12	6	19	3	8	3	6	2	2			1
Total injuries	18		22		11		9		3		1	

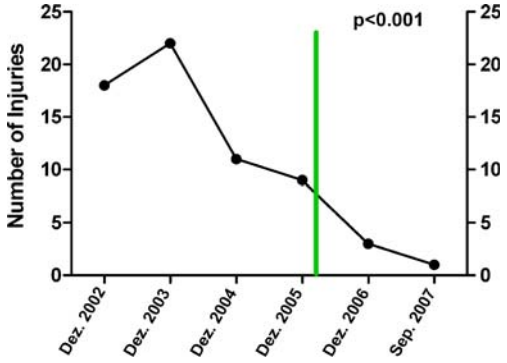

Fig. 3 Graph displaying the reduction of cutting and needle-stitch injuries after the introduction of cut-resistant gloves (*vertical bar*)

resulted in a medical examination. The mean costs for a medical examination and laboratory analyses in Berlin for a cutting–needle-stitch injury were 187.66 Euro in 2001. This is in line with the average costs reported from Bavaria and NRW. Costs due to administrational effort and lost working time were estimated above 200 Euro per case. Infections and further medical treatment were not included in these estimates. If included, the costs per case were above 4,000 Euro per year according to the accident insurance company of NRW. In the observation period, one of the cutting injuries included in our study resulted in a month-long prophylactic anti-retroviral therapy. Prices of the cut-resistant gloves were 7.45, 11.40 and 17.50 Euro (recommended retail price) per pair, respectively. For an institute with about 20 persons working in the analysed divisions, the overall costs for individual cut-resistant gloves would be between 149 and 350 Euro (about 210–495 US dollar).

Additionally, to the cutting injuries, four splashes in the eye were reported in the CPDL before the introduction of protective eyewear. Three of those splashes were officially registered and resulted in medical examinations. After the introduction of protective eyewear, no further incidences were reported.

Discussion

Blood-borne diseases like HCV and HIV are a global phenomenon with disease focusing mainly outside Western Europe. Still, also in this region, they do remain epidemiologically important diseases and constitute a potential danger for medical staff including pathologists [1, 3, 11–13, 17]. Standard occupational safety measures should take into account that an infection of a patient might be unknown to both clinician and pathologist at the time of tissue examination. Therefore, the mere enhancement of otherwise insufficient standard safety measures in the case of known infectious disease should be considered substandard and careless.

Concordant with our results, two orthopaedic studies found the thumb and the index finger, respectively, thumb, index finger, middle finger and palm most often affected by glove-perforating injuries [16, 23]. Dominant and non-dominant hand were affected almost alike [16, 23]. Although the number of cases was small (n = 8), Pritt and Waters [21] reported similar results in their study of cutting injuries in a pathology department. A possible explanation for the predominance of injuries at the non-dominant hand in our larger study could be the use of different, mainly larger, blades and needles with larger handles in comparison with surgical disciplines, which might make injuries of the cutting hand less likely. Differences in the results might also be attributed to the 15 cases with unknown handedness or side of injury in our study, although it seems very unlikely that all these cases could be attributed to the dominant hand.

From the eight cases in Pritt's study, two were especially interesting because cut-resistant gloves were worn by the affected physicians. In one case, the cutting injury occurred at the non-gloved cutting hand while the non-cutting hand was protected. In the other case, a microtome blade obviously cut through the cut-resistant glove and into the thumb of a resident [21]. Notwithstanding the institute in Pritt's study, microtome blades are not used for the dissection of surgical specimen in our department. Anyhow, we had only few microtome-caused injuries (n = 4) in the respective laboratory section and because we have not introduced cut-resistant gloves in this section we excluded them from our analysis. In a probatory experiment, when we tried to cut through the thin cut-resistant gloves from the CPDL (both types) with a microtome blade, we were unable to permeate the glove.

Kelly et al. compared doubled-latex gloves with the same combination of latex and cut-resistant gloves we used in a series of 12 consecutive intermaxillary fixation procedures and a test set of six cadaver heads. They demonstrated a significant reduction of glove perforation when using cut-resistant gloves [14]. Likewise, Pieper et al. have compared double-latex gloving, triple-latex gloving and gloving with Kevlar or stainless steel glove liners in 30 oral surgical procedures [20]. Although perforations in the Kevlar and stainless steel group occurred, protection was superior to that of double-latex gloving. Importantly, cut resistance was not tested in this study because all perforations could be attributed to wire puncture [20]. In a study on 50 orthopaedic procedures, no advantage for cut-resistant gloves was found [16]. Again, the punctures in this study were rather not attributable to blade injuries. However, in contrast, another randomised orthopaedic study on 118 operations did show a significantly higher perforation rate without cut-resistant gloves [23].

The relevance of percutaneous injuries in surgical disciplines has already been described and cut-resistant gloves are seen as potentially useful [15]. The majority of

injuries was due to needle stitches [15]. Considering the inferior protection of Kevlar-based cut-resistant gloves against puncture injuries in comparison with cutting injuries, the benefit of cut-resistant gloves is probably limited in these circumstances. Although puncture-resistant polyethylene gloves are commercially available, the cutaneous sensibility with these gloves was markedly reduced, questioning their usability [26].

As two injuries took place at unprotected hands after the introduction of cut-resistant gloves, it is obvious that wearing habits differed among the staff. An exact analysis of how often cut-resistant gloves were worn was not possible retrospectively. Generally, the younger residents (first to fourth year) accepted the use of cut-resistant gloves better than older physicians. The wearing habits of the autopsy staff varied from seldom to constantly. In the majority of cases, the cut-resistant gloves were worn on the non-dominant hand only. Arguments for this practice as well as for not wearing the gloves were better dexterity and sensitivity, for example when searching lymph nodes. Routine wearers of the gloves reported good adjustment to the gloves and only minimal restrictions, especially when wearing them only on the non-dominant side. Adjustment was even better in the autopsy divisions, probably attributable to the fact that less often microscopically small probes had to be handled.

Because needles were able to penetrate the used cut-resistant gloves, a reduction of these injuries could not be expected. That we still experienced a reduction in the year 2006 and 2007 might be due to a better care in the usage of needles possibly caused by an increased attention to occupational safety with the introduction of cut-resistant gloves. Because, for autopsy personnel, skin sensitivity is not of that high importance for exenteration, it is possible that the new puncture-resistant polyethylene gloves could prevent or at least further reduce needle-stitch injuries in this field of work. Until now, there exist no data on this issue, but we plan to test such gloves for this purpose in the future.

Another point to address is that possible important external parameters influencing the incidence rates of cutting injuries like number of employees in a division, number and type of cutting instruments, number of autopsies and number of surgical specimen did not relevantly change from 2002 to 2007. The number of injuries other than the included forms was rather low. These injuries were also infrequent in years with the highest cutting and needle-stitch injuries (2002 and 2004), increased in 2005 and 2006 and decreased little again in 2007. This argues against the possibility of a changed injury-reporting behaviour and supports the attribution of the observed changes to the use of cut-resistant gloves. However, the just significant drop ($p = 0.046$) in the number of injuries between 2002–2003 and 2004–2005 is difficult to explain. Meanwhile, even the drop from 2004–2005 to 2006–2007 is highly significant ($p = 0.009$). The observational study design does not allow for an absolutely doubtless attribution of the demonstrated improvements (decrease) in the numbers of injuries to the cut-resistant gloves, but considering all data given this seems at least to be a very likely and well-founded assumption.

Based on the authors' experiences, the study results and the review of literature, recommendations for the safe use of blades and needles in dissection and autopsy divisions are summarised in Table 2. Further experiments should be performed concerning the usefulness of polyethylene gloves instead of conventional cut-resistant gloves (see Table 2 point 4), especially for autopsy personnel.

Financially, even considering only the officially reported cases (15%, which is in line with estimations from the accident insurance company of NRW with around 80% unreported cases), the expenditures for medical treatments by the accident insurance companies exceed the costs for cut-resistant gloves by far. The use of cut-resistant gloves

Table 2 Recommendations for the safe use of blades and needles in pathologic dissection and autopsy divisions

Number	Recommendation
1	If blades are not necessary, they should be omitted and should be out of the normal elbowroom. Ideally, they could be placed in troughs or drawers but in clear view of the user. Blunt blades and needles should not be used but carefully replaced. Waste blades should be dropped into special one-way-open containers only—not just stored besides. The containers should be regularly emptied.
2	Direct pressure should not be executed on a blade with the hands (especially not without wearing cut-resistant gloves). Using hands–fingers to exercise counter-pressure for suturing should be avoided. If unavoidable, as much space as possible for the penetrating needle should be given.
3	External disturbance for the cutting or suturing person should be minimised.
4	Cut-resistant gloves should be worn in addition to doubled-latex–vinyl gloves ideally on both hands whenever possible. At least for the non-dominant hand, such gloves should be used whenever working with blades.
5	If an injury occurred, work should be stopped and the wound should be treated according to wound-adapted treatment plans. Injuries with blades or needles should be reported. Although time pressure and shortage of staff seem often to seriously hinder this, it is the responsibility for one's own health next to insurance-related reasons that should promote compliance in this essential matter.

seems therefore reasonable not only from the medical but also from a macro-economical point of view.

In conclusion, we demonstrated that cut-resistant protective gloves are a reasonable, effective and cost-effective safety measure in pathologic autopsy and dissection divisions. Although certainly underestimated, cutting injuries are not very frequent; however, they still constitute a relevant and specific danger to pathologists and autopsy staff. The procedures described in this study could significantly reduce their incidence rate.

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Conflict of interest statement We declare that we have no conflict of interest.

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