

Investigation of X-ray permeability of surgical gloves coated with different contrast agents

Mustafa Kayan, Selçuk Yaşar, Mustafa Saygın*, Ömer Yılmaz, Aykut Recep Aktaş, Fatmanur Kayan**, Yasin Türker***, Gürsel Çetinkaya

Departments of Radiology, *Physiology **Pulmonary Disease and ***Cardiology Faculty of Medicine, Süleyman Demirel University; Isparta-Turkey

ABSTRACT

Objective: We aimed to investigate the effectiveness and radiation protection capability of latex gloves coated with various contrast agents as an alternative to lead gloves.

Methods: The following six groups were created to evaluate the permeability of X-ray in this experimental study: lead gloves, two different non-ionic contrast media (iopromide 370/100 mg I/mL and iomeprol 400/100 mg I/mL), 10% povidone-iodine (PV-I), 240/240 g/mL barium sulphate and a mixture of equal amounts of all contrast agents. A radiation dose detector was placed in coated latex gloves for each one. The absorption values of radiation from latex gloves coated with various contrast agents were measured and compared with the absorption of radiation from lead gloves. This study was designed as an 'experimental study'.

Results: The mean absorption value of X-ray from lead gloves was 3.0 ± 0.08 µG/s. The mean absorption values of X-ray from latex gloves coated with various contrast agents were 3.7 ± 0.09 µG/s (iopromide 370/100 mg I/mL), 3.6 ± 0.09 µG/s (iomeprol 400/100 mg I/mL), 3.7 ± 0.04 µG/s (PV-I), 3.1 ± 0.07 µG/s (barium sulphate) and 3.8 ± 0.05 µG/s (mixture of all contrast agents). Latex gloves coated with barium sulphate provided the best radiation absorption compared with latex gloves coated with other radiodense contrast agents.

Conclusion: Latex gloves coated with barium sulphate may provide protection equivalent to lead gloves. (*Anatol J Cardiol* 2016; 16: 424-7)

Keywords: radiation, lead gloves, latex gloves, barium sulphate

Introduction

Despite the fact that lead gloves are used in interventional procedures, there are differences in X-ray attenuation, which may be associated with many factors such as the duration of the procedure and glove thickness (1). X-ray, which is used for many examinations and an interventional procedure, is a type of ionising radiation (1-3). There are many harmful effects of ionising radiation on living organisms. It is well established that the hands of healthcare workers are exposed to ionising radiation during interventional procedures (4, 5). Lead gloves have been developed for protection from those negative effects. However, they have some crucial disadvantages such as high cost, being disposable, reducing finger touch sensitivity and difficulty of manipulating because of certain thickness in order to prove protection from X-ray (6, 7).

In this study, we aimed to investigate the usefulness and X-ray permeability of latex gloves coated with various contrast agents (CAs) as alternatives to expensive and thick lead gloves.

Methods

The approval of the Local Ethics Committee was taken. We used lead gloves (Proguard Radiation Reducing Gloves RR-2, Emerson & Co. Genoa, Italy) and latex gloves (Beybi® Powder Free Sterile Surgical Gloves, Malaysia). The mean thicknesses of lead gloves were 0.30 ± 0.02 mm and lead equivalent of 0.020 mm. The mean X-ray absorption value of latex gloves was measured as 3.8 ± 0.06 µG/s. The following six groups were created to evaluate the permeability of the X-ray (Table 1): Group I, lead gloves; Group II, 50 mL of non-ionic monomeric CA iopromide (370/100 mg I/mL); Group III, 50 mL of non-ionic monomeric CA iomeprol (400/100 mg I/mL); Group IV, 50 mL povidone-iodine (PV-I, 10%); Group V, 50 mL of 240/240 g/mL barium sulphate (BS) and Group VI, mixture of all CAs (50 mL 370/100 mg I/mL of iopromide + 50 mL 400/100 mg I/mL of iomeprol + 50 mL PV-I + 50 mL BS). This study was designed as an 'experimental study'. Metal containers were used during the process of coating latex gloves with CAs. Then, CAs were placed into labelled metal containers.

Address for Correspondence: Dr. Mustafa Kayan, Hızır Bey Mah., 1556 S. Yunus Evler Sitesi B-Blok No:8, Isparta-Türkiye

Phone: +90 505 935 35 39 E-mail: drkayan32@hotmail.com

Accepted Date: 12.05.2015 Available Online Date: 14.07.2015

© Copyright 2016 by Turkish Society of Cardiology - Available online at www.anatoljcardiol.com
DOI:10.5152/AnatolJCardiol.2015.6389



Table 1. Study groups composed of different contrast agents.

Group I	Lead gloves (Control group)
Group II	Non-ionic CA (370/100 mg I/mL)
Group III	Non-ionic CA (400/100 mg I/mL)
Group IV	10% povidone–iodine
Group V	Barium sulphate (240/240 g/mL)
Group VI	Mixture of GII+GIII+GIV+GV

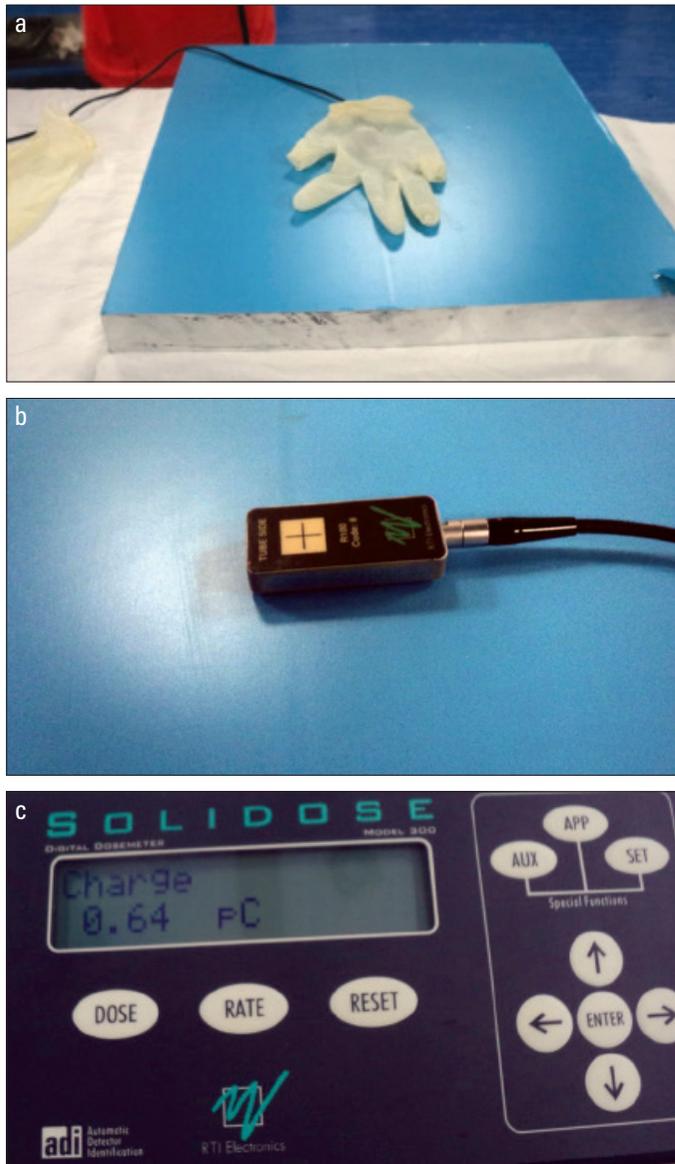


Figure 1 (a-c). An R-100 dose detector was placed into latex gloves at the midpoint of the phantom (a, b). An R-100 dose detector connected to Solidose-300 instant dose-measuring device (c)

The outer surfaces of the latex gloves were immersed into the metal container by holding them from the wrist portion so that the inner surfaces of the gloves were protected. Then, for stabilisation, non-coated latex gloves were passed on the latex gloves coated with CAs. The coatings of CAs onto the latex gloves were carried out separately for each group.

Radiation dose exposure was carried out under constant conditions and the same brand of latex gloves and lead gloves was used for standardisation of measurements. A radiation dose detector (Solidose-R-100) was placed inside the latex gloves coated with CAs. The Solidose-300 instant device was connected to the detector for measuring the radiation dose (Fig. 1). Radiation dose measurements were carried out by keeping the distance from the X-ray tube (about 70 cm) and X-ray dose constant (70 kV and 4.8 mA) separately for each group. Twenty repeated radiation exposures and dose measurements were performed for each group and recorded in terms of $\mu\text{G/s}$ (Fig. 2).

Statistical analysis

Distribution of radiation dose measurement data was evaluated using the Kolmogorov–Smirnov test and seen to be normally distributed. Comparison of the group means tested with analysis of variance (ANOVA) firstly. Duncan's multiple range test was used to determine the significance levels in pairwise comparisons. Correlation coefficients were calculated for determination of linearity between the groups. With a power of 80% and $\alpha=0.05$, the minimum number of subjects required for the comparisons was 20 for each group. A p value of less than 0.05 was considered significant. Statistical analyses were performed with SPSS for Windows 15.0 software package in Süleyman Demirel University Statistics Consulting Practice and Research Center.

Results

Comparison of X-ray permeability of surgical gloves coated with different CAs is shown in Table 2. The mean X-ray absorption values of lead gloves (Group I) were $3.0\pm 0.08 \mu\text{G/s}$. The mean absorption values of X-ray from latex gloves coated with CAs were $3.7\pm 0.09 \mu\text{G/s}$ (Group II), $3.6\pm 0.09 \mu\text{G/s}$ (Group III), $3.7\pm 0.04 \mu\text{G/s}$ (Group IV), $3.1\pm 0.07 \mu\text{G/s}$ (Group V) and $3.8\pm 0.05 \mu\text{G/s}$ (Group VI). Group I showed the highest X-ray protection. The protection value of Group V was significantly ($p<0.05$) higher than that of the remaining four groups. Group V showed similar X-ray protection values as Group I (3.1 ± 0.07 vs. $3.0\pm 0.08 \mu\text{G/s}$, $p>0.05$). When we evaluated the percentages of X-ray protection in all study groups, Group I and Group V showed the highest and second highest percentages were, respectively (Fig. 3).

Analysis of the correlation between the groups revealed a negative correlation in one portion of the groups and a positive correlation in another portion of the groups. A significant negative linear correlation ($r=-0.451$) was detected only between Group V and Group VI ($p<0.05$). While the X-ray absorption value or X-ray protection value increased in Group V, it decreased in Group VI.

Discussion

The protection value of BS-coated latex gloves was significantly higher than that of the remaining four groups and it had similar X-ray protection value as Group I in our study.

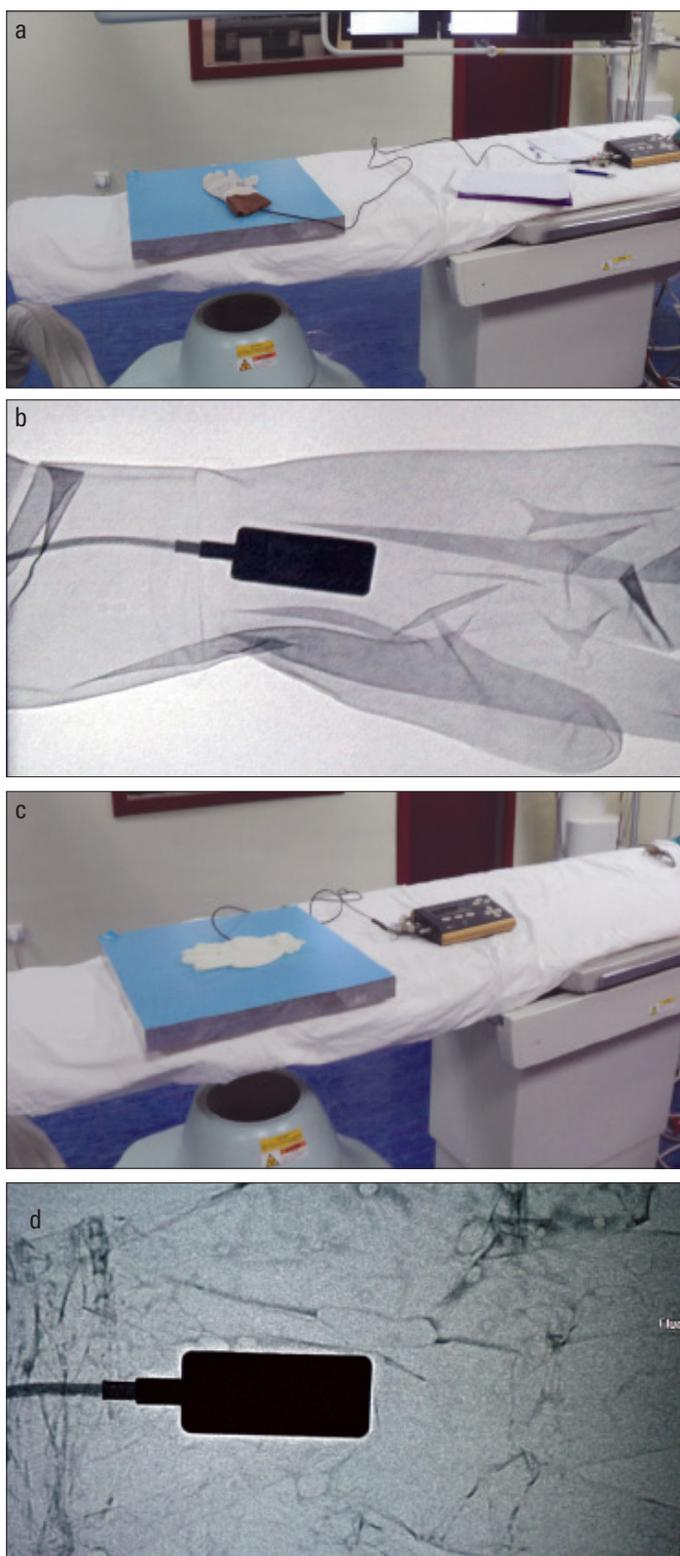


Figure 2 (a-d). Instant dose measurement samples in fluoroscopic device. After the exposure, an X-ray image of the R-100 detector connected to Solidose-300 instant dose-measuring device in lead gloves (a, b). Example of dose measurements of latex gloves coated with CAs and their X-ray image (c, d)

The hands of health care workers are the most commonly affected parts of the body during the interventional procedures using X-rays. It is recommended to use lead gloves to protect

Table 2. Comparison of X-ray permeability of surgical gloves coated with different contrast agents

Groups	X-ray absorption	P
Group I	3.0±0.08	<0.001
Group II	3.7±0.09	
Group III	3.6±0.09	
Group IV	3.7±0.04	
Group V	3.1±0.07	
Group VI	3.8±0.05	

P₁ (GI vs. GII), P₂ (GI vs. GIII), P₃ (GI vs. GIV), P₄ (GI vs. GVI), P₅ (GII vs. GV), P₆ (GII vs. GVI), P₇ (GIII vs. GIV), P₈ (GIII vs. GV), P₉ (GIII vs. GVI), P₁₀ (GIV vs. GV), P₁₁ (GV vs. GVI) <0.001; Other NS. Comparison of the group means tested with analysis of variance (ANOVA).

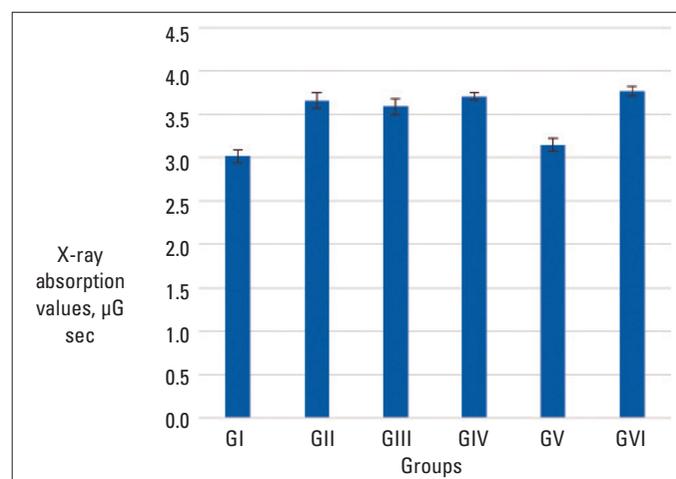


Figure 3. A graphical representation of the descriptive statistical analysis and significance level of the mean X-ray absorption values of the groups

the hands. If not adequately protected from X-ray, repetitive radiation exposures can trigger the development of cancer, especially on fingers, in later periods (8-10). The thickness and lead equivalent of lead gloves vary. The radiation protection of lead gloves depends on these. In our study, the thickness and lead equivalent of lead gloves were 0.30±0.02 mm and 0.020 mm Pb, respectively. These lead gloves are preferred widely for X-ray protection and easy manipulation.

Iodine and BS, as elements with high electron density and atomic number, absorb X-rays. Therefore, they are used in radiological examinations, such as angiography and computed tomography, as CAs for intravenous injection (11). Radiodense BS is insoluble in water and is not suitable for intravenous administration. It is usually used in clinical practice as a contrast media for X-ray imaging of gastrointestinal tract (12).

Lead gloves are also used as radiation protection in many medical procedures such as fluoroscopy-guided fracture reduction, percutaneous vertebroplasty and angiography (13, 14).

There are some disadvantages of lead gloves such as being disposable and requiring a certain thickness that limits touch sensitivity, restricted fine motor skills and hand manoeuvrability,

which may have negative effects on the outcome of the procedure (15).

In order to eliminate these problems, it is recommended to cut the distal ends of the fingers of lead gloves and wear sterile latex gloves on top of the lead gloves if necessary (7).

Although cutting the distal ends of the fingers of lead gloves eliminates problems to a certain extent, the radiation protection of such gloves decreases significantly compared with that of uncut or intact lead gloves (15).

We worked on a method that may eliminate these problems without cutting the distal ends of lead gloves. For this reason, we used various CAs with iodine and BS, having X-ray absorption properties. Latex gloves were coated with various CAs. The radiation absorption values of latex gloves coated with various CAs were measured and compared with those of lead gloves. Group I provided the best radiation protection in comparison with other groups. The difference between Group V and other groups of latex gloves coated with CAs (Groups II–IV and VI) in terms of X-ray protection were found to be statistically significant.

Addition of BS suspension or powdered barium into the dough during manufacturing of surgical latex gloves would allow homogeneous distribution in its. So, the radiation protection of surgical latex gloves may be increased.

Other advantages of BS-coated latex gloves are cost-effectiveness, availability and thinness. The thinness of BS-coated latex gloves may increase touch sensitivity, fine motor skills and hand manoeuvrability without cutting the distal ends of lead gloves.

To the best of our knowledge, there is only one study (7) about lead gloves for increasing touch sensitivity or hand manoeuvrability by cutting the distal ends of lead gloves. We did not find a similar study alternative to lead gloves in the literature review. So, we think that our study is the first such report.

Study limitations

Finger touch sensitivity of contrast media-coated latex gloves may be evaluated during angiographic interventional examinations. We may use more different CAs in our study.

Conclusion

Latex gloves coated with BS provide the best radiation protection in comparison with latex gloves coated with other radiodense CAs. It may provide protection equivalent to lead gloves and increase touch sensitivity, fine motor skills and hand manoeuvrability. Our experimental study results may be supported by clinical studies which assess the elasticity and finger touch sensitivity of latex gloves with BS during interventional procedures.

Conflict of interest: None declared.

Peer-review: Externally peer-reviewed.

Author contributions: Concept - M.K.; Design - M.K.; Supervision - M.K.; Resource - S.Y.; Materials - Ö.Y.; Data collection &/or processing - A.R.A.; Analysis &/or interpretation - F.K.; Literature search - G.Ç.; Writing - Y.T.; Critical review - Y.T.

References

1. Bushong SC. Radiologic Science for Technologist Seventh Edition St. Louis: Mosby; 1998.
2. Terato H, Ide H. Clustered DNA damage induced by heavy ion particles. *Biol Sci Space* 2004; 18: 206-15. [\[Crossref\]](#)
3. Tokuyama Y, Furusawa Y, Ide H, Yasui A, Terato H. Role of isolated and clustered DNA damage and the post-irradiating repair process in the effects of heavy ion beam irradiation. *J Radiat Res* 2015 Feb 25. Epub ahead of print. [\[Crossref\]](#)
4. Azzam EI, Jay-Gerin JP, Pain D. Ionizing radiation-induced metabolic oxidative stress and prolonged cell injury. *Cancer Lett* 2012; 31: 48-60.
5. Sert C, Çelik MS, Akdağ Z, Ketani MA, Nergiz Y. The radioprotective effect of vitamins C, E and Vitamin E + Glutathione on the small intestine and the thyroid gland in rats irradiated with X-rays. *Turk J Med Sci* 2000; 30: 417-25.
6. Dorne HL. Use of flexible protective gloves: another viewpoint. *Radiology* 1990; 176: 287-8. [\[Crossref\]](#)
7. Ullman JM. Increasing the usefulness of disposable lead gloves. *Radiology* 1990; 174: 581. [\[Crossref\]](#)
8. Kovalchuk O, Ponton A, Filkowski J, Kovalchuk I. Dissimilar genome response to acute and chronic low-dose radiation in male and female mice. *Mutat Res* 2004; 550: 59-72. [\[Crossref\]](#)
9. Abolfath RM, Carlson DJ, Chen ZJ, Nath R. A molecular dynamics simulation of DNA damage induction by ionizing radiation. *Phys Med Biol* 2013; 58: 7143-7. [\[Crossref\]](#)
10. Wagner LK, McNeese MD, Marx MV, Siegel EL. Severe skin reactions from interventional fluoroscopy: case report and review of the literature. *Radiology* 1999; 213: 773-6. [\[Crossref\]](#)
11. Obert M, Kohl LM, Graf N, Krombach GA, Verhoff MA. Contrast enhancement using curd and contrast agent mixtures for ex vivo vessel imaging in computed tomography. *Rofo* 2014; 186: 959-61.
12. Niikura R, Nagata N, Shimbo T, Akiyama J, Uemura N. Colonoscopy can miss diverticula of the left colon identified by barium enema. *World J Gastroenterol* 2013; 19: 2362-7. [\[Crossref\]](#)
13. Calder PR, Tennent TD, Allen PW. Assessment of the efficacy of Proguard RR-2 radio-protective gloves during forearm manipulation. *Injury* 2003; 34: 159-61. [\[Crossref\]](#)
14. Von Wrangel A, Cederblad A, Rodriguez-Catarino M. Fluoroscopically guided percutaneous vertebroplasty: assessment of radiation doses and implementation of procedural routines to reduce operator exposure. *Acta Radiol* 2009; 50: 490-6. [\[Crossref\]](#)
15. Kelsey CA, Mettler FA Jr. Flexible protective gloves: The emperor's new clothes? *Radiology* 1990; 174: 275-6. [\[Crossref\]](#)