의학석사 학위논문

Radiation Exposure on Eyes and Thyroid of Physician during Cervical Epidural Block

경부경막외 신경블록시 시술자의 눈과 갑상선에 노출되는 방사선 피폭량의 측정

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Background

Cervical epidural block is a technique often used by pain physicians and used to treat patients with cervical pain. The procedure requires frequent x-ray imaging, due to the possibility of severe complications, and the physcian performing the procedure is susceptible to frequent and high doses of radiation compared to other pain procedures. Thus firstly, we evaluated the radiation exposed to eye and thyroid of pain physicians when performing cervical epidural block and secondly, we checked the effectiveness of lead-based protection and compared radiation exposure between two differently experienced pain physicians.

Methods

The study was conducted on two pain physicians (a fellow and a professor) who performed C-arm fluoroscopy-guided cervical epidural block from 1 July 2013 to 31 August 2013. Among total of 7 dosimeters, 5 dosimeters were placed: on the forehead, inside and outside of the thyroid protector, and inside and outside of the lead apron. Two dosimeters were used as control. Age, sex, height, weight of patients, radiation exposure time, absorbed dose, and distance from the center of the X-ray field to the physicians were also collected.

Results

Ninety-six cervical epidural block procedures using C-arm fluoroscopy were performed in comparable patients over a 2-month period, 51 cases by a fellow and 45 cases by a professor. Only the distance from the center of the X-ray field to the physicians showed statistically significant difference (p=0.03). Lead based protection decreased the absorbed radiation dose up to 35%. The calculated annual equivalent doses of approximately 600 cases of CEB showed that radiation exposure of eyes and thyroid in this study were far below the annual maximum permissible radiation doses.

Conclusion

This study reveals that radiation exposure to the eyes and thyroid during CEB is far below the annual maximum permissible radiation doses. Damage from frequent low dose radiation exposure is yet to be fully understood; and thus, safety measures such as lead-based protection should always be enforced.

Keywords : Eye, physician, radiation protection, thyroid.

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Introduction

For the past 10 years, interventional procedures using fluoroscope in pain medicine has exponentially increased (1). Despite the growing concern on occupational radiation exposure (2-4), fluoroscopy is essential for accurate procedures with minimal complications. For example, when an epidural block is performed using a blind technique (loss of resistance method), the needle could be misplaced from the epidural space, with reports of 13 to 30% chance of misplacement (5,6).

Cervical epidural block (CEB) is often used to treat patients with cervical herniated intervertebral disc, spinal stenosis, etc (7,8). In the CEB, even more caution should be enforced as the epidural space is narrower than elsewhere; thus, severe complications such as spinal cord injury and paraplegia can easily occur (9-11). As a result, frequent fluoroscopic guided needle insertion technique is mandatory with CEB; and for utmost caution and accurate procedure, the head of the pain physician is often placed near the fluoroscope. Therefore, there may be a higher risk of radiation exposure to eyes and thyroid compared to other techniques (Fig. 1). Recent researches concerning the survivors from Hiroshima, Nagasaki, and Chernobyl nuclear disaster (12-14) and medical staff of interventional cardiology (15,16) or radiology (17,18) emphasized the high risk of cataract as a direct result of radiation to the lens of the eye. Subsequently, the International Commission on Radiological Protection (ICRP) lowered the maximum threshold for annual radiation dose to the eye from 150 mSv to 20 mSv (19); whereas, maximum annual radiation dose to the thyroid stayed at 500 mSv (20). While the danger of radiation exposure is being continuously re-evaluated, there has never been a study reporting the risk of radiation exposure for the CEB on the pain physician. Hence, the primary objective of this study is to check the actual radiation exposure during CEB to the pain physician's eyes and thyroid, and to reveal the risks and need for protection. Secondary objectives are to check the effectiveness of lead-based protection and compare the radiation exposure between two differently experienced pain physicians.

Materials and Methods

Physicians

This study was a prospective study that was performed for a period of two months, from July 1st 2013 to August 31st 2013, on radiation doses on the head and neck of pain physicians performing CEB. The subjects for the study were a well-experienced professor with over 4 years of practice and more than 2000 cases of CEB and a fellow with approximately 3 months of training having done approximately 100 cases of CEB.

Leaded protections

For leaded protection, a thyroid protector and an apron were used. The thyroid protector was a conventional collar method at 0.5mmPb and sufficiently shielding from the sternal notch to just below the chin when properly worn. The leaded apron was a coat type providing 360 degrees of shielding from the upper thigh to the wearer’s torso. The level of protection for the leaded apron was at 0.3 mmPb and 0.25mmPb at the front and back, respectively.

Measurements

For measuring the radiation dose, seven thermoluminiscent dosimeters (UD-802, Panasonic, Osaka, Japan) were used. During CEB, five of the thermoluminiscent dosimeters (TLD) were placed on the pain physician: inside and outside of the thyroid protector, inside and outside of the chest area of the lead apron, and one on the forehead (for measuring radiation exposure to the eyes) (Fig.2). Our pain center lacked the glass type TLD; hence, forehead dosimeter was a substitute. The forehead TLD was placed in a manner so that it would be placed as close as possible to the physician's eye without obstructing the field of vision. The remaining two TLDs were "control badges" with one being placed inside the operation room and the other being placed outside, more than 100 meters away from the operation room. The control badges were left for two months, which is the same period as the study. Time taken for the CEB procedure, radiation exposure time, radiation absorption dose (RAD) were collected through the C-arm fluoroscope (Ziehm Vision, Ziehm imaging GMBH, Nurnberg, Germany). The distance from the center of the X-ray field to the physician (Fig. 3) and the patient's age, sex, height, and body weight were also recorded. The distance was measured when the C-arm was placed within the operating field and once the physician got on the foot stool, positioning himself right next to the patient for the procedure. During the CEB, the physicians were told to minimize body movement and not to step down from the foot stool. The pain physician did not wear any leaded eyewear; and when not in use, the lead apron, thyroid protector, and the attached 5 TLDs were stored elsewhere from the operation room.

Cervical Epidural Block

Before the procedure, intravenous access was conducted. CEB was performed under sterile conditions using fluoroscopy while monitoring vital signs (blood pressure, pulse oximeter, and electrocardiogram). The patient was placed in prone position on a radiological table and the pain physician placed himself right next to the patient using a foot stool (as the operating bed was positioned high for the entry of C-arm). Once placing himself next to the patient, the pain physician never stepped down from the foot stool until the end of procedure, only bending or extending his back and neck and moving hands. Therefore throughout the procedure, the physician did not move his body very much, keeping a fairly constant posture. Besides the thyroid protector and lead apron, there were no other protective wear or devices such as leaded curtain or leaded glass shields. After suitable positioning for fluoroscopy, local anesthetics with 1 % lidocaine were injected on the site for skin pucture. A 20 gauge Tuohy needle (Tae-Chang Industrial Co., Kongju, Republic of Korea) was inserted at the C6-7 level by midline approach using anteroposterior images. When the needle was firmly engaged, a lateral view was confirmed. The needle was advanced using a loss-of-resistance (LOR) technique in order to identify the epidural space. After obtaining LOR, contrast media (iohexol, 300-mg iodine per ml; GE Healthcare, Piscataway, NJ) was injected for confirmation of the cervical epidural space. When all scout films were checked, radiation exposure time and RAD were measured. Also, while contrast media was injected, real time fluoroscopy was used in continuous mode.

Statistical Analysis

The demographic data of the patient, procedure time, radiation exposure time, absorbed dose, and distance from the x-ray field to the physician were collected. For statistical analysis, a t-test was performed using IBM® SPSS® Amos™ 20.0. Results are expressed as means of ± SD. The measured radiation doses from the TLDs for two months were calculated to annual equivalent doses.

Result

During the period of two months, 96 cases of CEB were performed on 96 patients: 51 by the fellow and 45 by the professor. The demographic data of the patients is summarized on table 1; the time taken for the CEB procedure, radiation exposure time, and radiation absorption time showed no significant difference between the two physicians (Table 1). Only the distance from the x-ray field showed a significant difference with the professor performing the CEB farther away from the fluoroscope ($p=0.03$).

The TLD placed on the forehead for the fellow and professor measured a radiation dose of 0.74 and 0.62 mSV respectively, which was similar to the radiation dose recorded on the outside of the lead apron (Table 2). Inside of the apron showed similar values to the control TLD, but inside of the thyroid protector showed slightly higher readings. Leaded protection provided reduction in radiation from at least 22 % and up to 35 % – almost as low as the control TLDs (Table 2). When each of the measurements were calculated to equivalent doses for 600 cases of CEB (our center's approximate annual CEB number per physician), every value showed much lower measurements compared to the annual acceptable radiation exposure dose set by ICRP (Fig.4).

Table 1. Demographic and radiation related data.

Physician	**Fellow**	**Professor**	**P value**
Patients	51	45	
Age (yr)	56.64 ± 12.40	54.20 ± 11.32	0.96
Sex (Male/Female)	25/26	22/24	
Height (cm)	163.02 ± 7.90	168.15 ± 1.32	0.21
Weight (kg)	63.05 ± 12.66	66.23 ± 6.12	0.27
Total time/procedure (sec)	803.4 ± 102	637.2 ± 78	0.35
Time of radiation exposure/procedure (sec)	22.96 ± 8.83	17.75 ± 2.40	0.18
Radiation absorption dose (cGy/cm2)	95.42 ± 66.15	89.94 ± 13.32	0.16
Distance (cm)	37.5 ± 2.04	41.2 ± 3.65	0.03

Table 2. The radiation dose measured with TLD (mSv).

Physician	TLD position	Radiation dose (mSv)	Difference of with or without protection (%)
Fellow	**Forehead**	**0.74**	
	Outside of thyroid protector	**0.55**	**22**
	Inside of thyroid protector	**0.43**	
	Outside of apron	**0.71**	**34**
	Inside of apron	**0.47**	
Professor	**Forehead**	**0.62**	
	Outside of thyroid protector	**0.47**	**32**
	Inside of thyroid protector	**0.32**	
	Outside of apron	**0.64**	**35**
	Inside of apron	**0.42**	
Room (control)	**Inside**	**0.4**	
	Outside	**0.37**	

Figure 1. CEB technique. (A) Lateral view of the CEB technique being performed by a pain physician, (B) Anterior view of the CEB technique being performed by a pain physician.

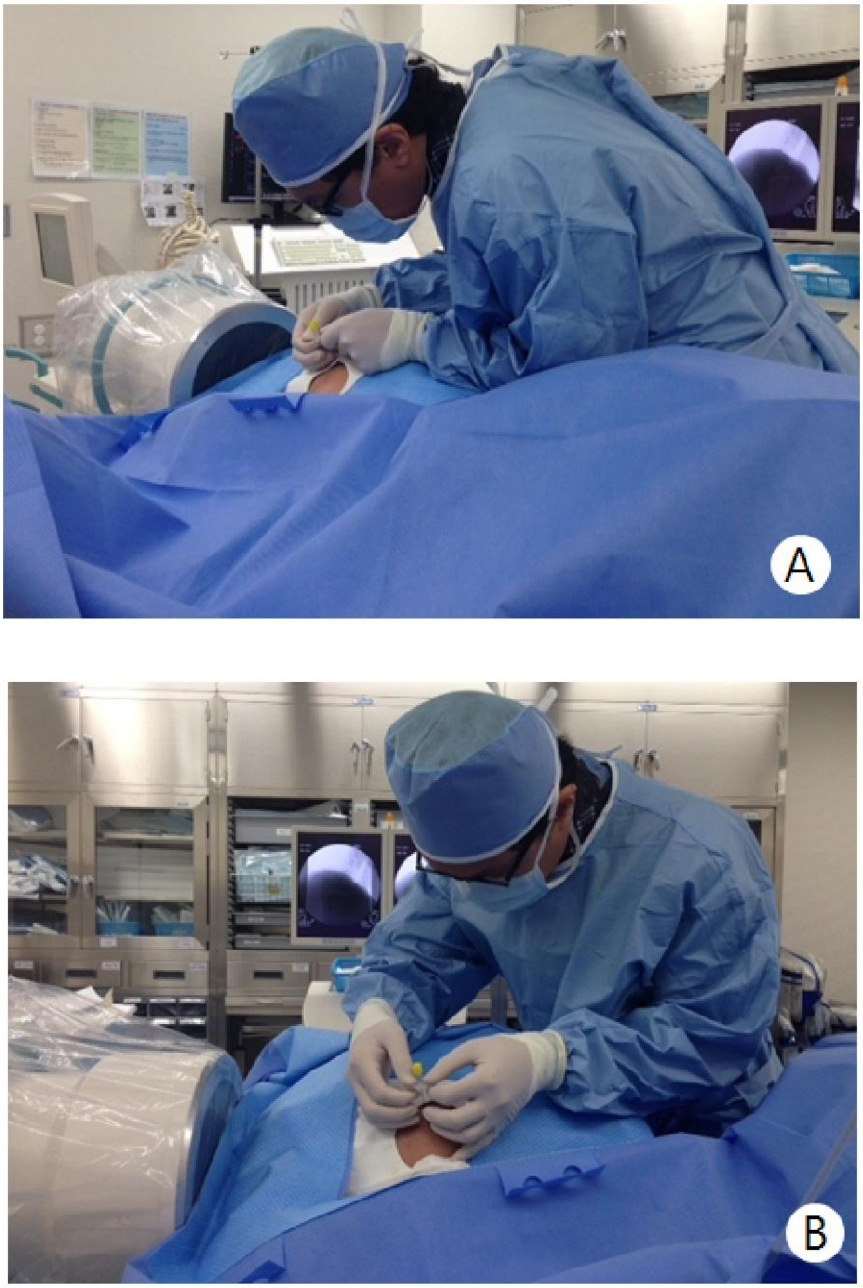


Figure 2. Placement of thermoluminiscent dosimeters (TLD). (A) Forehead TLD, (B) Outside of thyroid protector TLD, (C) Inside of thyroid protector TLD, (D) Inside of apron TLD, (E) Outside of apron TLD.

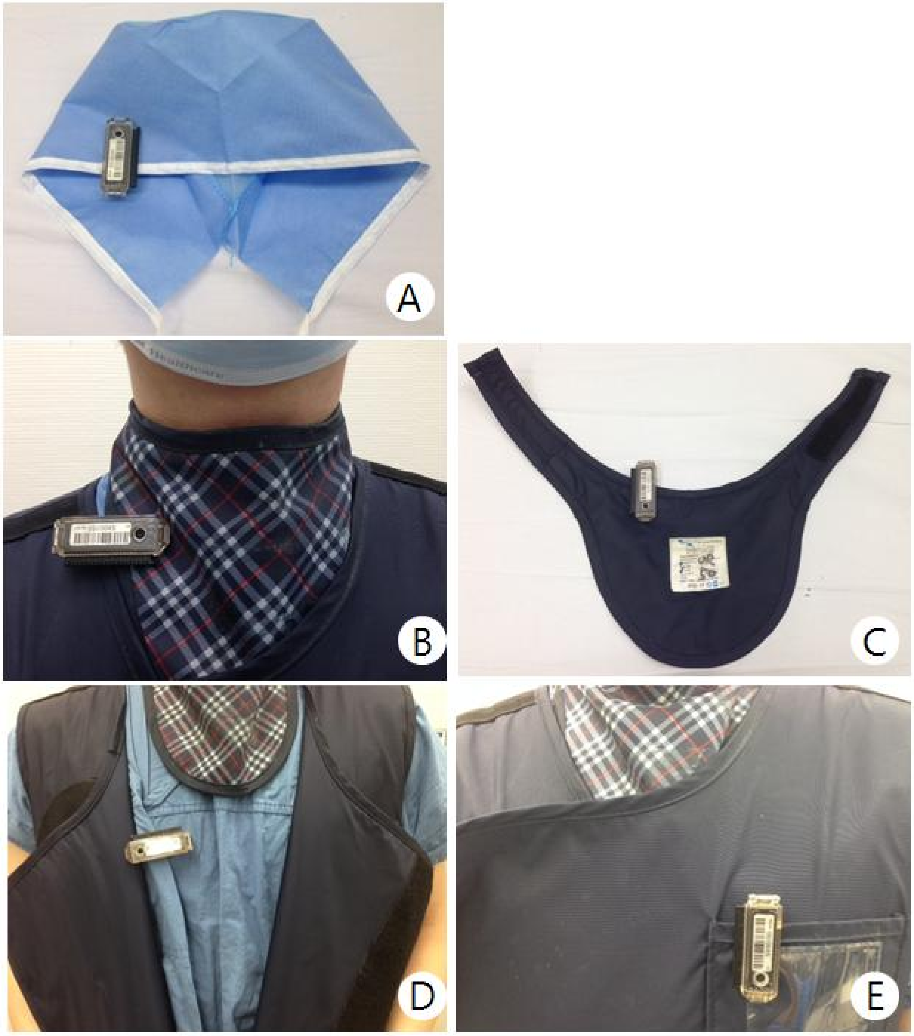


Figure 3. The distance (A) from the center of the X-ray field, (B) to the physician.

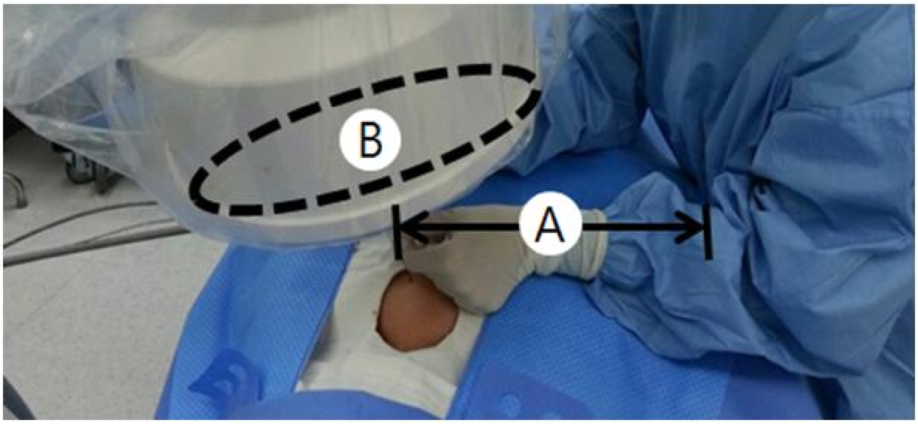
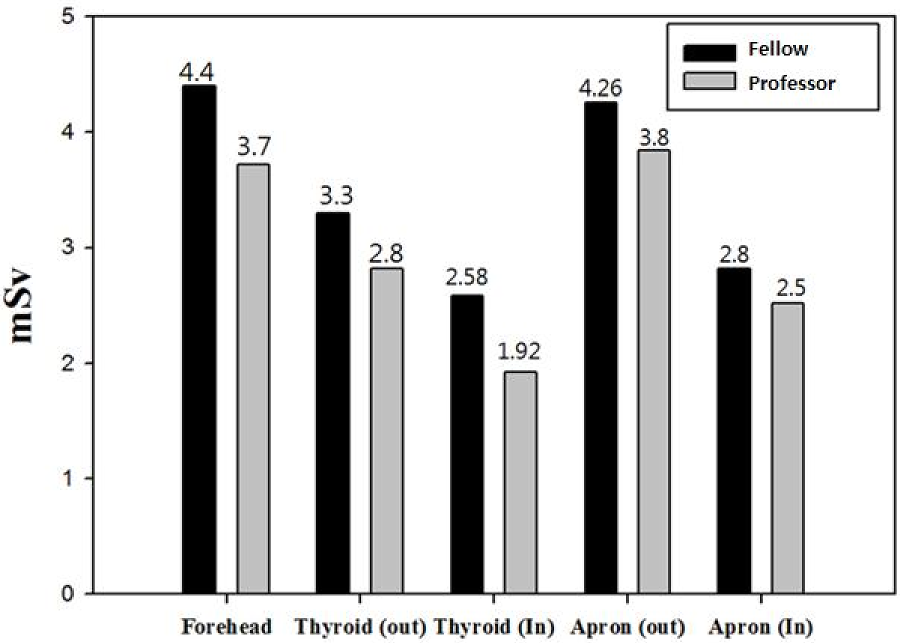


Fig. 4. Calculated annual equivalent dose (approximately 600 cases) exposure measured with TLD. Annual maximum target area/organ permissible radiation dose set by International Commission on Radiological Protection (ICRP) to thyroid and lens of eyes are 500 and 20 mSv, respectively.



Discussion

Fluoroscopy is vastly used in interventional pain managements. As a result, more studies are recently appearing concerning the radiation exposure for pain physicians (21,22). Most of the studies regarding the harm of radiation in the fluoroscopy guided interventions conclude with exposed radiation levels to be much lower than the yearly limit set by the ICRP (23-25); however, exposure to long-term, low levels of ionizing radiation cannot be accurately predicted. Furthermore, long-term exposure at low levels of ionizing radiation may not destroy the cell, but can lead to cell damage and mutation, possibly causing trouble years later (3). Epidemiologic studies from Hiroshima, Nagasaki, and Chernobyl nuclear disaster revealed that low dose radiation exposure may lead to cataracts (12-14). Therefore, pain physicians should understand the risk of radiation exposure during fluoroscopy guided intervention and take caution to minimize occupational radiation exposure. We focused on the radiation exposure during CEB for two reasons. Firstly, the physician is more likely to work closer to the radiation beam for careful manipulation. Radiation exposure is known to be inversely proportional to the distance from the radiation source (26). Through cadaver studies, a 100 fold increase in radiation dose was recorded when getting closer to radiation source from 30 cm to 15 cm (27); and only 0.1% of the radiation reached at 100 cm (21). Thus, staying close to the radiation beam may be a risk factor for pain physicians. Secondly, pain physicians position themselves near to the patient during CEB. In our study, the distance between pain physician and the x-ray field for the fellow was only 37.5 ± 2.04 cm. Such proximity may increase the exposed radiation dose on the physician, as it is more likely for scattered radiation beam from the patient's body to reach the pain physician's head (28), which leads to our primary objective. Because of such possibility, we hypothesized the increased exposure in radiation on the eyes and thyroid. In our study, forehead TLD showed the highest radiation dose as expected, reaching as high as 4.44 mSv on the fellow when converted to annual equivalent dose (approximately 600 cases annually) (Fig. 4). The forehead TLD and outside of apron TLD recorded similar radiation doses in both physicians. In contrast, outside of thyroid TLD showed values almost equally low as that of the inside of apron TLD. Such unusual results may be explained by the habit of pain physicians flexing their heads for a better visual of the injection site (resulting in tucking their chin, possibly blocking radiation from entering the thyroid). Nonetheless as with other values without lead-based protection, even forehead TLD showed radiation dosage well below the ICRP's limits. Additionally, our study was performed without any leaded eyewear protection, in order to replicate the usual clinical field as many pain physicians still refrain from wearing any eye protective gear.

For the secondary objective, we checked the efficacy of lead protection and whether clinical experience affected radiation exposure. All measured radiation doses with lead-based protection in our study were far below the annual maximum permissible radiation dose set by ICRP. Again, the importance of shielding is justified. ICRP's three main principles for reducing unnecessary occupational radiation exposure are justification, optimization, and dose limitation (20). Justification is ensuring that "more good is done than harm" when using harmful radiation. Optimization basically means that radiation doses should be kept "as low as possible", taking social, medical, and economic considerations. For dose limitation, another three factors are responsible: time, distance, and shielding (29). Reducing time of exposure decreases the radiation proportionally. Skilled physician have an advantage in reducing time of exposure. In our study, radiation exposure time of the professor was shorter than that of the fellow, despite being statistically insignificant. Also, the professor was significantly farther from the x-ray field compared to the fellow, reflecting the difference in awareness of radiation safety. Shielding literally means shielding one’s body from radiation rays usually by wearing leaded products (apron, gloves, goggles, etc). Leaded apron that is 0.5mm thick is known to reduce the exposed radiation up to 99% (30) and leaded eye wear reduces radiation up to 70 % (31). However, in this study, protection rates were lower than those of previous reports; the reductions in radiation dose by means of leaded apron and thyroid protector were 34 - 35% and 22 – 32%, respectively. This may be the result of a thinner apron (0.3mmPb at front) and from possible defects in our leaded protective gears. Oyar found that in his hospital, only 15.3% of the aprons were at normal protective levels and 68.2% were found to be defective according to their method of storage and care (37). Even the normal aprons showed folds providing leaks for radiation to enter. Unfortunately, our study did not use a new apron or thyroid protector. As a result, the thyroid protector and the lead apron could have had defects in them, skewing the actual results.

Many physicians are not properly educated on protective equipment and the harm of occupational radiation exposure (32, 33). A pilot test on fellows with at least a year of clinical practice showed that a mere 33% received proper radiation safety education, and the educated group was more likely to use protective gear (34). In addition, in an educational environment, the radiation exposure time is estimated to be twice to 14 times longer in comparison to procedures performed by skilled physicians (35).

Our study showed that eyes are more susceptible to radiation compared to thyroid. This concurs with ICRP's recent decision to lower the yearly maximum radiation dose to the eye from 150mSv to 20mSv. In contrast to apron and thyroid protectors, which are widely used, the actual use of leaded eyewear among pain physicians is unknown. During fluoroscopy guided medical practice, the pain physician almost always places him/herself near the patient, increasing the risk of radiation damage to the eye by scattered radiation from the patient. Thus, leaded eyewear must be enforced. Furthermore, the ideal position of the physician's head would be in a 90 degree angle from the scattered radiation. Without optimal positioning of the head, the leaded eyewear may be rendered useless, so appropriate tilting of the head should also be considered (36). Overall, leaded protection appears to be an obligation and clinical experience did have an effect on radiation exposure for physicians, specifically by means of distancing oneself farther from the radiation beam.

The limitation to our study is that only one procedure was considered. Using just a single technique and applying it for an annual radiation dose for the pain physician would be unrealistic in a normal clinical setting. Further research on various techniques would give a more realistic annual radiation dose. Also, our study calculated the annual dose using only two months of data. A future study, collecting the actual annual radiation measurements, is deemed to be necessary.

Conclusion

The primary concern for high radiation doses may not need to be worried during the cervical epidural block technique done under proper protective gears. However, uncertain damage that may result from frequent low doses of radiation should not be undermined and safety techniques must always be complied.

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초록

배경

경부 경막외 신경차단술은 통증 전문의들이 경부 통증을 치료하기 위해 자주 사용하는 시술이다. 심각한 합병증의 가능성을 줄이기 위해 경부 경막외 신경차단술은 다른 통증조절 시술에 비해 빈번하고 높은 용량의 방사선 촬영이 요구된다. 본 교실에서는 경부 경막외 신경차단술을 시행하는 시술자들의 안구, 갑상선에 노출되는 방사선량 측정 및 납성분이 들어간 보호장비의 효용성에 대해 연구하였다.

방법

본 연구는 2013년 7월1일부터 2013년 8월31일 까지 방사선 투시영상을 사용하여 경부 경막외 신경차단술을 시행한 두 명의 시술자 (펠로우와 교수)가 참여되었다. 총 7개의 방사선 선량계 중 5개는 이마, 갑상선 보호구 안,밖 그리고 납가운 안과밖에 위치하였고 2개는 대조군으로 사용되었다. 또한 성별, 나이, 신장, 몸무게, 방사선 피폭량, 시간, 흡수량 그리고 통증 전문의와 방사선의 중심으로부터의 거리가 측정되었다.

결과

방사선 투시영상을 이용한 96개의 경부 경막외 신경차단술을 받은 96명의 환자가 참여되었고 두 통증 전문의에 의해 각각 51명, 45명의 환자가 시술을 받았다. 시술자와 방사선의 중심으로부터의 거리만이 유일하게 통계적으로 유의하였다 ($p=0.03$). 납성분의 보호장비는 방사선 흡수량을 최대 35%까지 줄이는 효용성을 보였다. 본 연구에서 경부 경막외 신경차단술 하면서 안구와 갑상선에 노출 되는 연간 등가선량(본원 센터 기준으로 일년에 약 600례)은 연간 최대 허용 방사선량보다 낮게 측정되었다.

결론

본 연구는 경부 경막외 신경차단술에서 안구와 갑상선의 연간 등가선량이 연간 최대 허용 방사선량보다 낮게 측정됨을 보였다. 빈번한 저용량 방사선 노출에 의한 피해에 대해 아직 연구가 부족한 실정이므로 방사선 노출에 대한 정확한 이해와 안전 장치의 필요성이 강화되어야겠다.

주요어: 눈, 시술자, 방사능 보호, 갑상선.

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