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# An Experimental Comparative Study of Radiography, Ultrasonography and CT Imaging in the IV Catheter Fragment

## - 정맥내 카테터 조각의 엑스선, 초음파 및 CT 영상의 실험적 비교 연구 -

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— Abstract —

The objective of this study was to detect the fragments generated during IV (intravenous) catheter injection of contrast medium and drug administration in a clinical setting and removal was performed by experimentally producing a phantom, and to compare the radiography, ultrasonography, and multi-detector computed tomography (MDCT) imaging and radiation dose. A 1 cm fragment of an 18 gage Teflon® IV catheter with saline was inserted into the IV control line. Radiography, CT, and ultrasonography were performed and radiography and CT dose were calculated. CT and ultrasonography showed an IV catheter fragment clinically and radiography showed no visible difference in the ability to provide a useful image of an IV catheter fragment modality ($p > .05$). Radiography of effective dose ($0.2139\ mSv \cdot Gy^{-1} \cdot cm^{-2}$) form DAP DAP ($0.93\ \mu Gy \cdot m^2$), and dose length product (DLP) ($201\ mGy \cdot cm$) to effective dose was calculated as 0.483 mSv. IV catheter fragment were detected of radiography, ultrasonography and CT. These results can be obtained by menas of an excellent IV catheter fragment of detection capability CT. However, CT is followed by radiation exposure. IV catheter fragment confirming the position and information recommend an ultrasonography.

**Key words:** Computed Tomography, Intravenous Catheter, Radiography, Ultrasonography, 3D imaging

## I. INTRODUCTION

Computed tomography (MDCT) scan for injection of drugs and contrast agents using an intravenous (intravenous) catheter and an automatic injector is used for the test. The IV catheter can be broken during removal due human error, leaving a broken fragment of a catheter in a vein. IV catheter fragment and embolization has been reported[1]. Also a risk of cardiovascular disease, and infection caused by the cut IV catheter were recently reported[2-4].

The most common complication associated with the use of catheters and mechanical injectors within the veins is swelling and compartment syndrome of the soft tissue surrounding blood vessels, and other vascular leakage also decreased the quality of care[5-6].

IV catheter fragments can cause potentially serious complications associated with intravenous catheters used for bolus injection of contrast agent for embolisms, and often accompanied by serious or fatal complications[7].

On CT, the density of tissue is used for imaging of a material, radiography imaging was used for

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detection of material with a low density. Recently the use of 3D MDCT has enabled the precise localization and detection of small relatively radiolucent foreign bodies[5]. However, CT is inevitably accompanied by radiation exposure. Ultrasonography avoids radiation exposure; in this study a non-invasive device is also compared to determine the effectiveness of ultrasonography, radiography, and CT imaging.

In this study, an implanted experimentally produced intravenous phantom catheter fragment caused by human error in injection of clinical contrast agents and drugs was used, and radiography was compared with ultrasonography and MDCT with removal of the catheter fragment was easier, which will the quality of patient care.

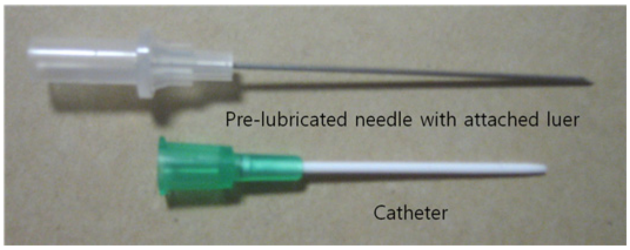


Fig. 1 A peripheral intravenous catheter composed of a pre-lubricated needle with attached luer and catheter

Fig. 2 Photography shows the IV catheter fragment inserted into the IV control line

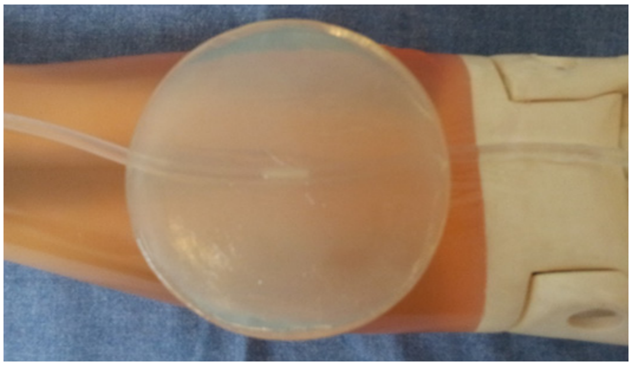

Fig. 3 Conforming gel pad stays in place easily conforming to contours of IV line parts with the anthropomorphic phantom

## II. MATERIALS AND METHODS

### 1. IV Catheter Fragment Phantom

IV catheter fragment phantom length 1 cm was prepared a Teflon 18 gauge IV catheter (diameter, 1.3 mm; length, 30 mm; BD IV Catheter; Becton Dickinson Korea, Seoul, Korea) (Fig. 1).

IV catheters using my sculpture IV control line were inserted (internal diameter, 3 mm Insung Medical, Seoul, Korea). An intravenous saline solution by inserting a catheter fragment was produced in the control line phantom (Fig. 2).

An adult anthropomorphic phantom (PBU-50, Kyoto Kaguku, Kyoto, Japan) upper placed of the IV control catheter phantom was used (Fig. 3).

### 2. X-ray Image

The radiation device was a Philips Digital Diagnose VR generator (IR-1100-150; Philips Medical Systems, The Netherlands) at 40 kVp, 50 mA, 1.1 mAs with 22 msec and exposure with the IV control line placed in the anthropomorphic phantom (Fig. 4). The images transferred to PACS were calculated by DAP (dose area product) in the DICOM header viewer. Conversion factor (0.23) for the calculation of effective des form DAP[8].

### 3. Ultrasonography

A 12 MHz phased array probe using the ultrasonography iU22 (Philips Healthcare, Andover, MA, USA). The ultrasonography phantom study was performed by an experienced radiation technician. For superficial structure visualization of posterior acoustic enhancement of the focus area has always had a B mode ultrasonography gel pad (2 × 9 cm; Aquaflex; Parker Laboratories, Fairfield, NJ, USA) raise and ultrasonography gel to the IV control line, scans to the images were obtained (Fig. 3).

### 4. CT and 3D Imaging

In CT, 2.5 mm of 120 kVp, 150 mAs 1.25 pitch and scan of the anthropomorphic phantom. An IV catheter was placed in the phantom CT scanner (Phillips Health Care, The Netherlands) an HU was determined.

Images acquired with 2.5 mm slice thickness. IV catheter with MDCT radiation dose CTDI vol and the DLP of the fragment were calculated, the European CT guidance (EUR 16262EN) (0.023 mSv·mGy−1·cm−1), effective dose (mSv) was calculated by multiplying the DLP[9].

CT images are transferred from PC–based 3D reconstruction software (Rapidia Infinitt, Seoul, Korea) to installed workstations. Multiple images of a phantom fragment IV catheter shaft obtained on CT scans are displayed. For the axial direction and a maximum intensity projection (MIP) image and the volume rendered image, a display window, and the level is optimized for a given contrast density.

Volume rendering is optimized for the reconstruction of the opacity; 100%, HU threshold range; it was set to 150–1480. The accuracy and size of the peripheral veins were evaluated to determine the HU values in a pilot study of the profile and table functions of the PC software the HU values of fragments of IV catheters were calculated. The study is small, so that the reform of the MDCT can be easily formatted, subtle veins localized volume rendering technique shows the utility of my catheter. The best fragment of the image within the vein catheter was described as a threshold range. MDCT is an excellent method for obtaining a three–dimensional volume rendering of the IV catheter fragment for evaluation of HU.

### 5. Statistical Analysis

The images were evaluated by two participating professional radiologists and clinical career for 10 years five radiological technologists. Based on ratings using a 5–point Likert scale analysis of radiography, ultrasound, and CT imaging is very excellent image (5), good image (4), fair image (3), bad imge (2), on a scale not seen (1) were used of fragment of IV catheter shown in the image (Table 1).

Intra–observer agreement was tested using Cohen's kappa coefficient. For statistical analysis, ANOVA (two–way analysis of variance) was performed to assess the effect of IV fragment on the observer's performance. Statistical analysis was performed with a statistical software package (IBM SPSS Statistics for Windows, Version 21, Chicago, IL, USA). The level of significance was set at a *p*–value of .05.

## III. RESULTS

Radiography, ultrasonography, and CT images of a fragment of a catheter inserted into a vein removed through a surgical procedure were analyzed. Radiography images were evaluated as excellent in the radiography image (Fig. 4), the exposure parameter of the radiography diagnostic images obtained from an IV

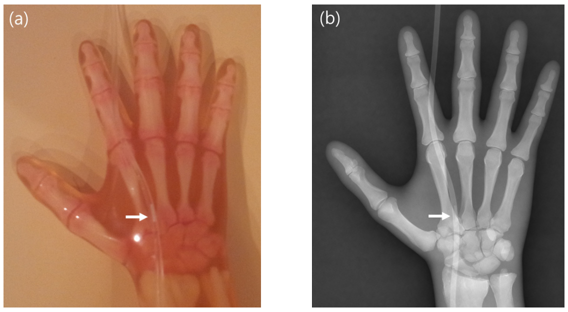


**Fig. 4** Phantom of an IV catheter fragment inserted in the phantom (A). Radiography showing the linear radio-opaque shadow of the IV catheter in the line (B)

**Table 1** Basic criteria used for image quality analysis

| Grade | Assessment | Definition |
|---|---|---|
| 5 | Excellent image | Excellent resolution of details and excellent visibility |
| 4 | Good image | Good resolution of details |
| 3 | Fair image | Insufficient resolution of details |
| 2 | Bad image | Details not resolved |
| 1 | No image | Invisible |

**Table 2** DAP at a fixed tube voltage and tube currents in radiography

| Tube voltage (kVp) | Tube current (mA) | DAP ($\mu\mu Gy \cdot m^2$) | Effective dose ($mSv \cdot Gy^{-1} \cdot cm^{-2}$) |
|---|---|---|---|
| 40 | 50 | 0.93 | 0.2139 |

**Table 3** CT scanning of dose of CTDIvol and DLP during monitoring

| MDCT | CTDIvol(mGy) | DLP(mGy · cm) | Effective Dose (mSv) |
|---|---|---|---|
| 64 | 9.5 | 210 | 0.483 |

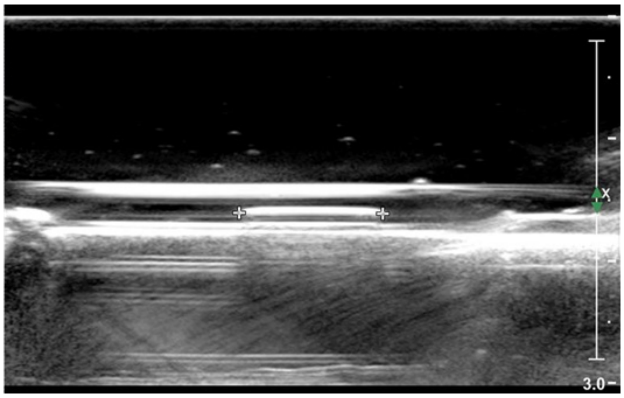

**Fig. 5** Ultrasonography shows the IV catheter fragment

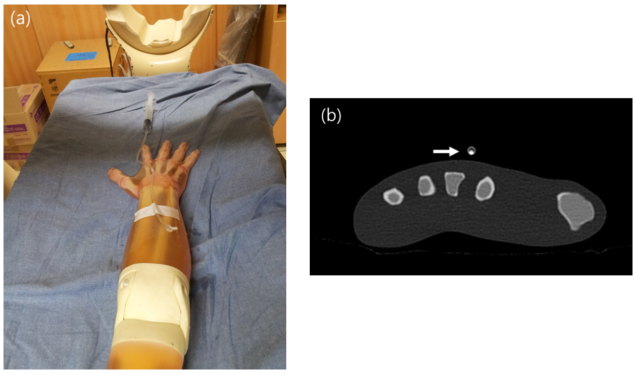


**Fig. 6** CT study of an IV catheter fragment in the phantom (A). Axial CT scan image of an IV catheter fragment (B)

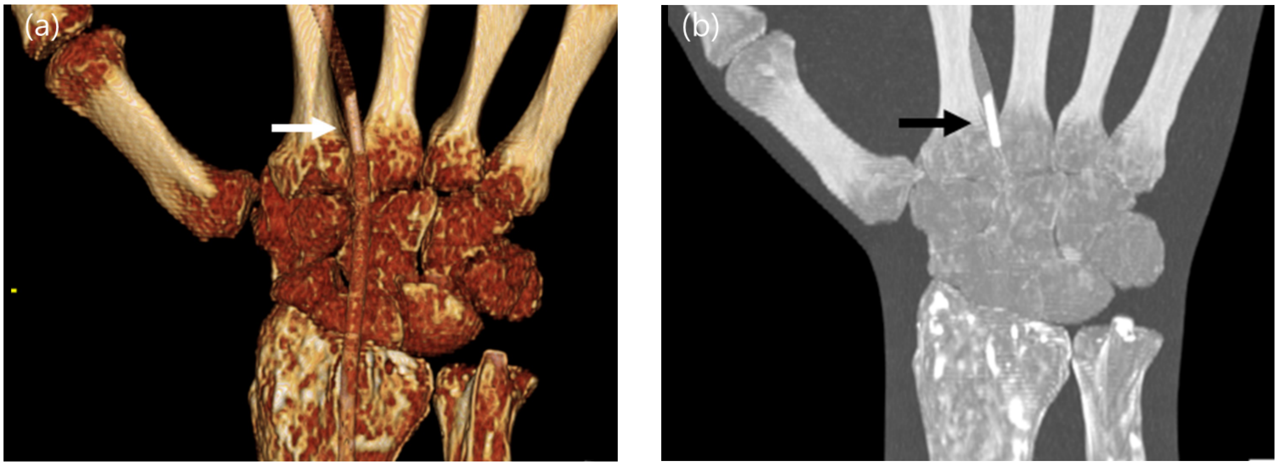


**Fig. 7** Three dimensional volume rendering of the CT data performed at the time of the study clearly demonstrates an IV catheter fragment (arrow) in the venous catheter (A). MIP view displays an IV catheter fragment (arrow) in the IV flow control line (B)

catheter fragment measured using DAP was 0.93 μ Gy·m$^2$ and effective dose (0.2139 mSv·Gy$^{-1}$·cm$^{-2}$) (Table 2).

On ultrasonography imaging catheter fragment was sharp and displayed the IV control line (Fig. 5).

CT axial image (Fig. 6) of an IV catheter fragment from MDCT volume rendering to acquisition, the fragment is well displayed in the 3D image (Fig. 7a), and a fragment within the catheter around the vein is clear in 3D imaging of the maximum projection intensity (Fig. 7b).

The CT CTDIvol was 9.5 mGy, DLP was calculated at a dose of 210 mGy·cm, the effective dose was 0.483 mSv (Table 3).

**Table 4** Image quality of IV catheter fragment in various modalities

| Modality | Grade | *p*-value |
|---|---|---|
| Radiography | 3.38 ± 0.32 | P 〉.05 |
| Ultrasonography | 4.18 ± 0.27 | |
| CT (volume rendering) | 4.38 ± 0.31 | |
| CT (MIP) | 4.25 ± 0.24 | |

Ultrasonography and CT images were evaluated by a very good image in the display IV catheter fragment compared to radiography examination (Table 4). Intra-observer variation as evaluated using Cohen's kappa coefficient was also moderate, with kappa below 0.7 for all observers.

## Ⅳ. DISCUSSION

Complications caused by intravenous injection of contrast media may occur unexpectedly. The IV catheter fragment must be removed within a short time because the fragment position affects the risk of thrombus generation and pulmonary embolism. Both potential and serious complications associated with the use of an IV catheter for bolus injection of contrast agent include serious accidents[10]. Dangerous situations may occur due to systematic human errors[11]. Ultrasonography is effective in finding a fracture of a surface structure of the internal organs and is non-invasive. In bones of children, when X-rays are necessary to visualize the fracture for detection of these subtle injuries, due to lack of calcium radiography is not always appropriate. Ultrasonography can identify microscopic inflammation of the bone over the displacement of the bone or cartilage. Ultrasonography examination of the veins in the IV control line of the fragment catheter may be a safe and accurate method of detection compared with X-ray due to the radiation protection. Hazards of X-rays include radiation exposure at a very low dose of radiation, such as IV catheters detected in children and pregnant women, thus examination by ultrasonography is recommended. In the current experimental study, IV catheters were made of a polytetrafluoroethylene (Teflon®) castle minutes, and the surface was coated with five stripes of barium sulfate. And a very sharp needle used for insertion of the IV catheter can be operated by withdrawing the cutting needle. IV catheter fragments are displayed, but intravenous catheterization is rarely performed and a number of generated X-ray imaging methods, such as ultrasonography or CT can be used for detection of the remaining fragment in the vein[12]. In general cases, such as an X-ray case of the IV catheter fragment and[13], most cases involving a catheter fragment, distal catheter fragment removal is successful with a small incision, and can be imaged and detected with simple removal in the emergency room. IV catheter fragments are small (〈1 cm) and thus may not be easily detected by radiography[4]. The IV catheter fragment may not be visible in radiography images on the axial CT scan, and a 3D image may be required to demonstrate the intravenous[14]. In CT MPR (multi-planar reformation), MIP, volume Rendering, a 3D reconstruction of the SSD was made using the scanned data from a catheter fragment to the MDCT located within the veins, helping to determine the position and confirm the size and catheter fragment in the vein by 3D reconstruction, in this study as volume rendering and MIP images it was helpful in showing the IV catheter fragment. In addition, 3D reconstruction techniques are used to measure the threshold of the volume rendering and to produce an image of an IV catheter fragment by changing the threshold setting of the HU within the catheter fragment of MDCT to determine the exact location and size within the vein. It is a very important factor in determining the exact location and size of the catheter fragment. In this study we set the threshold value from 150 to 1480 for the best implementation of the volume rendering image[15]. The inability to visualize the IV catheter fragment may ultimately depend on the position of the fragment in which case the ultrasonic catheter can be seen using another method[16]. Management options for maintaining the broken catheter are determined by the likelihood of infection and injury areas. In cases involving an IV catheter fragment, blood in the wrists and hands is affected first; when cutting in the position of maintenance of the IV catheter fragment from the contrast medium, the intravenous injection site was measured and insertion required a catheter sheath vein; we compared the circulation[17]. DLP is a critical factor in calculating the effective dose. In this study, results of analysis were multiplied by a constant to the DLP to determine the effective dose, the DLP in comparison to European diagnostic reference level (DRL) in DLP is 210 mGy·cm on CT[7]. CT was reported to have greater capacity for detection of debris compared to radiography and ultrasonography, but involves exposure to the CT dose[18]. Checking the patient doses can eliminate the risk, so the detection is lower than standard doses will be required by depending on the size and position of the fragment. However, if detection can be achieved by the ultrasonic scan, ultrasonography, rather than other radiography and CT scan, is recommended to prevent exposure of the patient.

## Ⅴ. CONCLUSION

Radiography, ultrasonography and CT detects and localizes IV catheter fragment with phantom. CT is more effective technique for visualization of IV catheter fragment in phantom than radiography and ultrasonography. However, due to radiography exposure dose and the accompanying expansion of the position and information on the IV catheter fragment, use of ultrasonography examination is recommended.

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**•국문초록**

# 정맥내 카테터 조각의 엑스선, 초음파 및 CT 영상의 실험적 비교 연구

**권대철**

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조영증강을 위해 조영제를 정맥내 카테터로 주입하는 과정에서 정맥태 카테터 조각을 검출하고 제거하기 위해 식염수와 18 게이지 테프론 IV 카테터의 1cm 조각을 삽입하여 팬텀을 제작하여 엑스선, 초음파 및 CT 영상을 비교하고자 한다. 엑스선, 초음파 및 CT에서 정맥내 카테터 조각을 임상적으로 유용하게 보였고, 조각의 묘출 능력에는 차이가 유의한 차이가 없었다.($p$〉.05). 방사선 선량은 엑스선에서 DAP (0.93 $\mu$Gy · m$^2$) 및 유효선량 (0.2139 mSv · Gy$^{-1}$ · cm$^{-2}$), CT의 DLP (201 mGy · cm), 유효선량은 0.483 mSv로 산출되었다. 엑스선, 초음파 및 CT에서 정맥내 카테터 조각을 임상적으로 검출하였고, 조각의 묘출 능력에는 CT가 우수하였다. 그러나 엑스선 및 CT는 방사선 피폭을 수반하여 정맥내 카테터 조각의 위치 및 정보를 확인하는 데는 초음파 검사를 추천한다.

**중심 단어**: 전산화단층촬영, 정맥내카테터, 엑스선검사, 초음파, 3차원영상