









# Is a Camera-Type Portable X-Ray Device Clinically Feasible in Chest Imaging?: Image Quality Comparison with Chest Radiographs Taken with Traditional Mobile Digital X-Ray Devices

카메라형 휴대형 X선 장치는 흉부 촬영에서 임상적 사용이 가능한가?: 기존의 이동형 디지털 X선 장치로 촬영한 흉부 X선 사진과 영상품질 비교

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**Purpose** To evaluate whether the image quality of chest radiographs obtained using a camera-type portable X-ray device is appropriate for clinical practice by comparing them with traditional mobile digital X-ray devices.

**Materials and Methods** Eighty-six patients who visited our emergency department and underwent endotracheal intubation, central venous catheterization, or nasogastric tube insertion were included in the study. Two radiologists scored images captured with traditional mobile devices before insertion and those captured with camera-type devices after insertion. Identification of the inserted instruments was evaluated on a 5-point scale, and the overall image quality was evaluated on a total of 20 points scale.

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**Results** The identification score of the instruments was  $4.67 \pm 0.71$ . The overall image quality score was  $19.70 \pm 0.72$  and  $15.02 \pm 3.31$  ( $p < 0.001$ ) for the mobile and camera-type devices, respectively. The scores of the camera-type device were significantly lower than those of the mobile device in terms of the detailed items of respiratory motion artifacts, trachea and bronchus, pulmonary vessels, posterior cardiac blood vessels, thoracic intervertebral disc space, subdiaphragmatic vessels, and diaphragm ( $p = 0.013$  for the item of diaphragm,  $p < 0.001$  for the other detailed items).

**Conclusion** Although caution is required for general diagnostic purposes as image quality degrades, a camera-type device can be used to evaluate the inserted instruments in chest radiographs.

**Index terms** Radiography, Thoracic; X-Ray; Thorax

## INTRODUCTION

Chest radiographs are one of the most commonly used diagnostic medical images. Among the general X-ray tests conducted nationwide, chest radiographs account for the largest proportion (approximately 25%) (1).

Diagnostic X-ray tests typically use a fixed device in an independent space designed to shield against radiation. However, a mobile X-ray device is used for patients who cannot move to the examination room owing to various restrictions. Traditional mobile X-ray devices weigh approximately 400 kg and are bulky, which limits their movement and portability. In addition, their high purchase and maintenance costs restrict their use at medical sites.

With a weight of approximately 2 kg, the recently developed camera-type portable X-ray device is lightweight, small, portable, and inexpensive to purchase and maintain. These devices are mainly used to inspect small areas, such as the hands and feet, and areas with less movement due to breathing.

With the coronavirus disease 2019 (COVID-19) pandemic, the demand for chest radiographs in places other than medical institutions has increased. To meet this demand for chest radiographs in mobile settings, traditional mobile X-ray and camera-type devices are increasingly used. It has been established that chest radiographs obtained using traditional mobile X-ray devices have appropriate image quality for diagnostic purposes (2, 3). However, camera-type X-ray devices have been used without proper verification (4).

This study aimed to compare the image quality of chest radiographs obtained using a camera-type portable X-ray device with that obtained using a traditional mobile digital X-ray device and to evaluate whether it can be used in clinical practice.

## MATERIALS AND METHODS

This single-center prospective study was approved by the Clinical Trial Ethics Committee of Korea University Guro Hospital, and informed consent was obtained from all patients. (IRB No. 2020GR0305).

## SUBJECTS OF STUDY

Among the patients who visited the emergency room between September 2020 and May 2021, adult patients aged 19 or older who inserted endotracheal tubes, central venous catheters, and nasogastric tubes after undergoing chest radiography using traditional mobile digital X-ray devices were eligible for the study.

The emergency medicine doctors who participated in the study explained to the patients' guardians that they would take chest radiographs using a camera-type portable X-ray device to assess the location of the instruments inserted or any complications related to the procedure. A total of 86 patients gave consent for participation and were included in the study.

## CHEST RADIOGRAPHS

Chest radiographs were obtained in the emergency room while the patient was lying down, and the X-ray generator was positioned between 1 to 1.5 m from the detector behind the back, considering the body type. Chest radiographs were acquired using a traditional mobile digital X-ray device under the specified parameters: tube voltage of 90 kVp, tube current of 250 mA, and an exposure time of 0.0128 seconds. Additionally, radiographs were obtained using a camera-type portable X-ray device (REMEX-KA6, REMEDI Co., Seoul, Korea) with the following settings: tube voltage of 70 kVp, tube current of 6 mA, and exposure time of 0.4 seconds. (Fig. 1) REMEX-KA6, a camera-type portable X-ray device used in this study, was approved by the Ministry of Food and Drug Safety of Korea in 2020 and by the United States Food and Drug Administration in 2021.

Fig. 1. Images of a traditional mobile digital X-ray device (A) and a camera-type portable X-ray device (B).



## EVALUATION OF IMAGE QUALITY OF CHEST RADIOGRAPHS

Two thoracic radiologists (H.S.Y., 18 years of experience; S-J.K., 4 years of experience) rated the overall image quality of the chest radiographs obtained using two different X-ray devices before and after the insertion of the instruments. Identification of the inserted instruments was evaluated on a 5-point scale (Table 1), and the overall image quality was evaluated on a total of 20 points scale (Table 2) (5-7). A 5-point scale was set based on the visibility of the tip of the instruments, which is the most important component of insertion instrument evaluation.

## STATISTICAL ANALYSIS

The mean and standard deviation of the total score and each detailed item score of the two evaluation criteria were calculated. The quality of chest radiographs obtained using the two different X-ray devices was compared using a paired *t*-test. All statistical analyses were performed using SPSS version 18 (IBM Corp., Armonk, NY, USA).

## RESULTS

Of the 86 patients who participated in the study, 59 (68.6%) were male, with a mean age of 69 years.

The mean evaluation score for whether the inserted instruments were clearly visible on chest radiographs obtained using a camera-type portable X-ray device was  $4.67 \pm 0.71$  points. There were 69 patients (80.2%) with 5 points, 7 (8.1%) with 4 points, 9 (10.5%) with 3 points, and 1 (1.2%) with 2 points (Figs. 2, 3).

The evaluation scores for overall image quality were  $19.70 \pm 0.72$  and  $15.02 \pm 3.31$  for the traditional mobile digital X-ray devices and camera-type portable X-ray devices, respectively (Fig. 4). The overall evaluation scores of the camera-type portable X-ray devices were significantly lower than those of the traditional mobile digital X-ray devices ( $p < 0.001$ ). Except for the items "internal and unexplained artifact" and "rib margin," there was a statistically significant difference in scores for all detailed evaluation items. Among these, there was a relatively large difference in the 'respiratory motion artifact' item scores (Table 3).

## DISCUSSION

To our knowledge, this is the first study to verify the image quality of chest radiographs obtained using portable camera-type X-ray devices. This was pursued by comparing the image

**Table 1.** Evaluation Criteria for the Identification of the Insertion Instruments

Evaluation Contents	Score
Entire portion including tip of the instrument is clearly visible	5
The tip of the instrument is clearly visible, but the remaining portion is not clearly visible	4
The tip of the insertion instrument is not clearly visible	3
Only a part of the insertion instrument is visible with limited evaluation	2
The insertion instrument is barely visible	1

Table 2. Evaluation Criteria for the Overall Image Quality

		Evaluation Contents	Score
Artifact	Internal and unexplained artifact	None	2
		Present, but no problem to evaluation	1
		Limitation for evaluation	0
	Respiratory motion artifact	None	2
		Present, but no problem to evaluation	1
		Limitation for evaluation	0
Resolution and contrast	Trachea and bronchus	Only trachea is clearly visible	3
		Trachea and main bronchus are clearly visible	2
		Segmental bronchi are clearly visible	1
	Right pulmonary vessels in the entire lung field	The peripheral 1/3 of the lung field vessels is clearly visible	3
		The middle 1/3 of the lung field vessels is clearly visible	2
		Only the central 1/3 of the lung field vessels is clearly visible	1
	Left pulmonary vessels in the entire lung field	The peripheral 1/3 of the lung field vessels is clearly visible	3
		The middle 1/3 of the lung field vessels is clearly visible	2
		Only the central 1/3 of the lung field vessels is clearly visible	1
	Pulmonary vessels behind the heart and descending aorta	Clearly visible	2
		Visible, but not clear	1
		Not visible	0
	Thoracic intervertebral disc space	Clearly visible	2
		Visible, but not clear	1
		Not visible	0
	Blood vessels below the diaphragm	Clearly visible	1
		Visible, but not clear	0
	Diaphragm	Clearly visible	1
Visible, but not clear		0	
Rib margin	Clearly visible	1	
	Visible, but not clear	0	

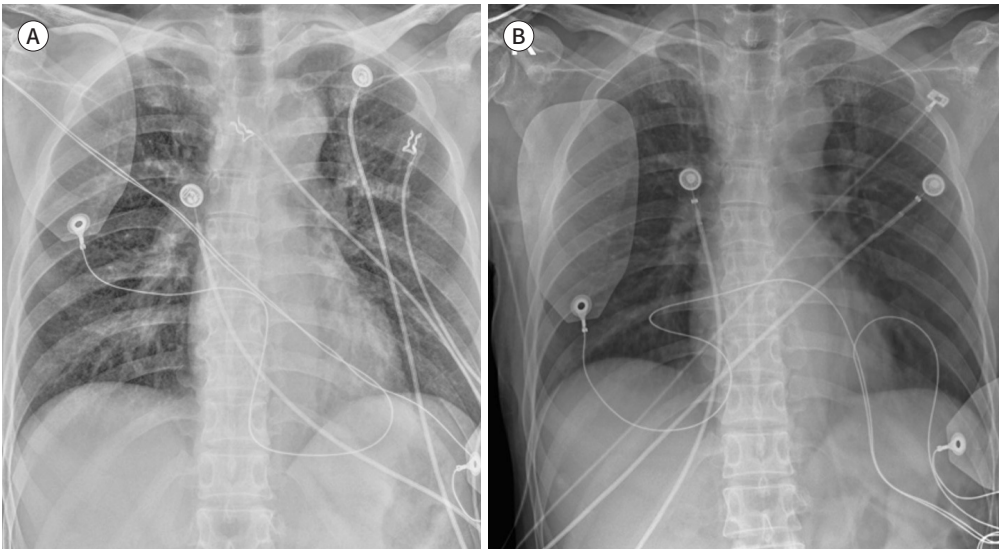
quality of chest radiographs obtained using a traditional mobile digital X-ray device.

Most patients (80.2%) scored 5 points in evaluating the instruments inserted on chest radiographs taken with a camera-type portable X-ray device; only one patient showed severe movements with limited evaluation. However, the overall image quality evaluation score was significantly lower than that of images obtained using traditional mobile digital X-ray devices. Even when examined in detail, all items except internal and unexplained artifacts and rib margins showed statistically significant differences.

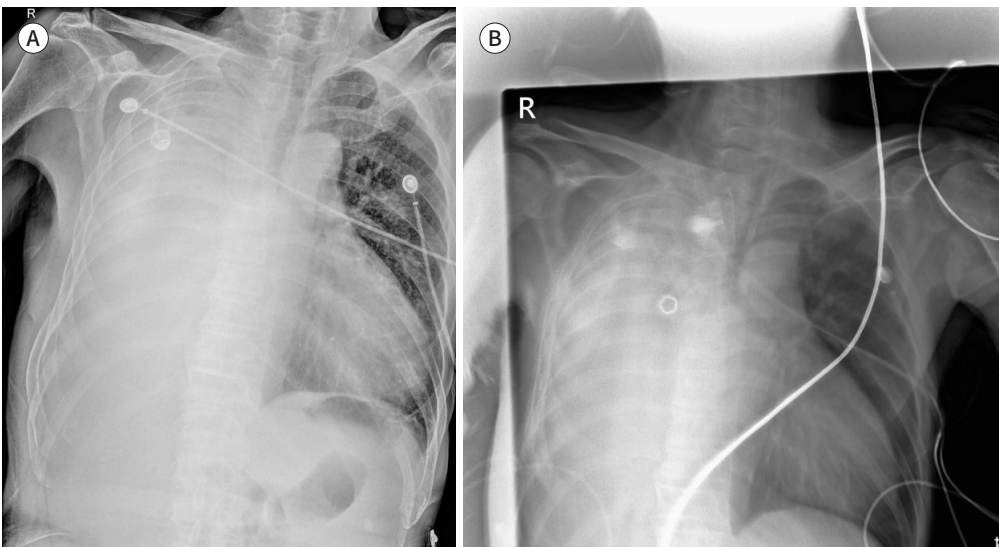
Among them, the largest difference in proportion was observed in the 'respiratory motion artifact' item scores. This is because the radiation output of the camera-type portable X-ray device is weak, and the exposure time required to obtain adequate image quality is quite long (0.4 seconds). Also, there was a large score difference in the details of the outer vessel and bronchial evaluation of the camera-type portable X-ray device because of its low resolution owing to its low voltage.

Camera-type portable X-ray devices are much smaller and lighter than traditional mobile

**Fig. 2.** Chest radiographs in a patient who underwent central venous catheter insertion; images were obtained with a traditional mobile X-ray device (A) before insertion and with a camera-type portable X-ray device (B), and image (B) scored 5 in the identification of the insertion instrument.



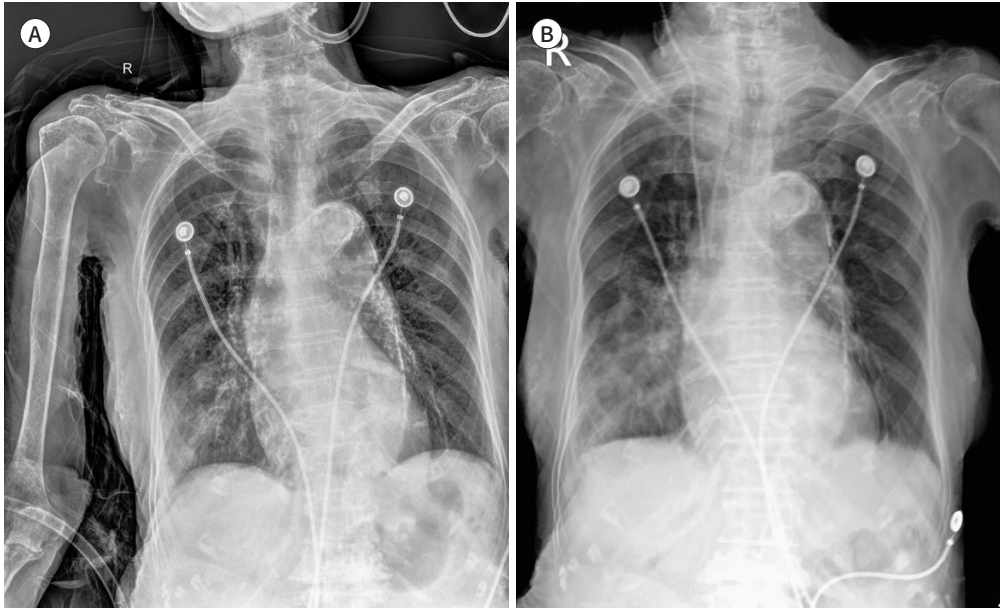
**Fig. 3.** Chest radiographs in a patient who underwent endotracheal intubation; images were obtained with a traditional mobile X-ray device (A) before insertion and with a camera-type portable X-ray device (B), and image (B) scored 2 in the identification of the insertion instrument.



digital X-ray devices, making them easier to use. In addition, the tube current and voltage in camera-type portable X-ray devices are lower than those in traditional mobile devices, thereby lowering the radiation risk. However, camera-type portable X-ray devices cannot obtain chest radiographs of sufficient quality for diagnostic purposes because of their long exposure times and low outputs. Although not for general diagnostic purposes, they can be useful for evaluating inserted instruments in chest radiographs.

This study has a few limitations. First, this study targeted a limited group of patients who underwent chest radiography to evaluate the instruments inserted among all patients who

**Fig. 4.** Chest radiographs in a patient who underwent central venous catheter insertion, with images obtained with a traditional mobile X-ray device (A), which scored 20 in overall image quality, and with a camera-type portable X-ray device (B) that scored 15; image (B) had a deduction of 1 point each from the following details: respiratory motion artifact, trachea and bronchus, right/left pulmonary vessels in the entire lung field, blood vessels below the diaphragm.



**Table 3.** Comparison of Camera-Type Portable and Traditional Mobile Devices

	Camera-Type Portable Devices	Traditional Mobile Devices	p-Value
Internal and unexplained artifact	1.98 ± 0.15	2 ± 0	0.159
Respiratory motion artifact	1.35 ± 0.55	2 ± 0	<0.001
Trachea and bronchus	2.26 ± 0.58	2.99 ± 0.11	<0.001
Right pulmonary vessels in the entire lung field	2.12 ± 0.80	3 ± 0	<0.001
Left pulmonary vessels in the entire lung field	2.14 ± 0.75	3 ± 0	<0.001
Pulmonary vessels behind the heart and descending aorta	1.47 ± 0.59	1.95 ± 0.21	<0.001
Thoracic intervertebral disc space	1.56 ± 0.61	1.94 ± 0.24	<0.001
Blood vessels below the diaphragm	0.26 ± 0.44	0.83 ± 0.38	<0.001
Diaphragm	0.92 ± 0.28	0.99 ± 0.11	0.013
Rib margin	0.99 ± 0.11	1 ± 0	0.320
Total	15.02 ± 3.31	19.70 ± 0.72	<0.001

Data are mean ± standard deviation values.

visited the emergency room of a single institution. Second, the sample size of this study may not have been sufficiently large. Third, image quality was evaluated by only two radiologists.

In conclusion, chest radiographs obtained with a camera-type portable X-ray device can be used to evaluate inserted instruments; however, caution is required when using them for general diagnostic purposes.

### Author Contributions

Conceptualization, all authors; data curation, K.S., Y.Z.; investigation, Y.H.S., K.J., Y.Y.; methodology, K.S., Y.H.S.; resources, Y.H.S.; supervision, Y.H.S., K.E.; validation, K.S., Y.H.S.; writing—original draft, K.S.; and writing—review & editing, K.S., Y.H.S.

### Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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## 카메라형 휴대형 X선 장치는 흉부 촬영에서 임상적 사용이 가능한가?: 기존의 이동형 디지털 X선 장치로 촬영한 흉부 X선 사진과 영상품질 비교

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**목적** 카메라형 휴대형 X선 장치를 이용하여 촬영한 흉부 X선 사진의 영상 품질을 기존 이동형 디지털 X선 장치로 촬영한 영상과 비교하여 임상에서 사용 가능한지 평가하고자 하였다.

**대상과 방법** 2020년 9월부터 2021년 5월까지 응급실에 내원한 환자 중 기관내 삽관, 중심정맥관, 비위관 등을 삽입한 86명의 환자를 대상으로 하였다. 환자들은 기구 삽입 전 기존 이동형 디지털 X선 장치, 기구 삽입 후 카메라형 휴대형 X선 장치를 이용하여 각각 흉부 영상을 촬영하였다. 두 명의 영상의학과 의사가 얻어진 두 영상을 삽입기구의 식별에 대하여 5점 척도, 전반적인 영상 품질에 대하여 20점 만점으로 평가하였다.

**결과** 카메라형 휴대형 X선 장치로 삽입한 기구의 식별에 대한 평가는  $4.67 \pm 0.71$ 점이었다. 전반적인 영상 품질에 대한 평가는 기존 이동형 디지털 X선 장치와 카메라형 휴대형 X선 장치가 각각  $19.70 \pm 0.72$ 점과  $15.02 \pm 3.31$ 점( $p < 0.001$ )이었고, 호흡 및 움직임 관련 인공물, 기관 및 기관지, 폐혈관, 심장 뒤 혈관, 흉추 추간관 공간, 횡격막 하 혈관, 횡격막 관찰의 세부 항목에서 카메라형 X선 장치의 점수가 통계적으로 유의하게 점수가 낮았다(횡격막 관찰 세부항목  $p = 0.013$ , 그 외 세부항목  $p < 0.001$ ).

**결론** 카메라형 휴대형 X선 장치는 흉부 X선 사진에서 삽입 기구의 평가를 목적으로 사용하는 것은 가능하나 영상의 품질 저하가 있으므로 일반적인 진단 목적의 사용에는 주의를 요한다.

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