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Mobile computed tomography scanner in trailer: a field hospital experience

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Abstract. – OBJECTIVE: Our study aimed at examining the use of a mobile computed tomography (CT) trailer in a field hospital.

MATERIALS AND METHODS: CT images of 540 patients were evaluated retrospectively. The images were subjectively divided into three groups according to their quality (good/moderate/poor). The CT region was divided into six regions (brain/thorax/abdominal pelvis/spinal/extremity/others). Mobile CT examinations were performed with a 128-slice CT scanner.

RESULTS: The most common clinical indications were trauma (34%) and pneumonia (31%). CT image quality was 95% good, 4.5% moderate and 0.5% poor. The frequency of imaging of regions was 38% thorax, 23.5% brain, 22% abdominal-pelvis, 9% spinal, 6% extremity, 1.5% others. In many cases, significant pathologies were diagnosed.

CONCLUSIONS: The use of a mobile CT trailer in the field hospital can make a positive contribution to patient management. The ease of assembly, as well as transportation and radiation safety of the mobile CT trailer, are suitable for the conditions of the field hospital.

Key Words:
Computed tomography, Mobile, Field hospital, War, Pandemic, Natural disaster.

Introduction

The inception of computed tomography (CT) in the early 1970s marked an important milestone in diagnostic radiology[1]. With CT, the first of the modern cross-sectional imaging modalities, internal images of the human body were obtained non-invasively[2]. Mathematically reconstructing images from measured data, digitally displaying and archiving them was a major innovation at the time[3]. After the invention of magnetic resonance imaging in the 1980s, the clinical use of CT was expected to decline. However, CT has shown a steady upward trend in terms of technology, performance and clinical use to date, and CT is still the most widely used imaging modality in radiology[2,4].

Field hospitals are temporary hospitals established to provide emergency medical services in cases of war, earthquake or epidemic/pandemic diseases[5]. The term, which was first used in military medicine, began to be used in disasters, epidemics and similar civilian situations[6,7]. The purpose of these hospitals is to provide safe health care and to identify patients who need to be referred to a better-equipped hospital[8]. In patients admitted to the field hospital, a quick and accurate diagnosis is very important[7,8]. The main advantages of the CT scan are that it is fast and allows for quantitative evaluation[9]. CT is an imaging method with high sensitivity, especially in pathologies such as trauma, acute abdominal pain and cerebrovascular disease[10]. For these reasons, it can be said that the duration of stay in the field hospital is directly related to CT, with further referral to the center and rapid treatment[9-12].

A mobile CT has been another important development in diagnostic radiology[13]. In standard conditions, the CT scanner is fixed, and it is necessary to transport the patient to the device[13]. A Mobile CT has been used in units where there might be difficult and risky patients to be transported, such as trauma, operating rooms, and intensive care units[14]. It has been used to ensure rapid diagnosis and minimize infectious risk in the COVID-19 pandemic[15]. It has been reported that mobile CT used in the hospital is diagnostically sufficient and cost-effective[16,17]. However, the image quality of mobile CT is low compared to the standard CT scanner[17].

We are reporting in this study our experience with a mobile CT scanner in trailer in a military field hospital. Our aim was to discuss the usability and advantages-disadvantages of mobile CT trailer.

Materials and Methods

Approval for this retrospective study was granted by the Institutional Ethics Committee of

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Turgut Özal University (2021/78). In our study, 540 patients with CT images were evaluated in the military field hospital in the Eastern Anatolia region of Turkey, between August 2019 and October 2021. The primary patient population was military personnel. Since the hospital was located in a rural area, it provided services to the civilian population as required. The age, gender and clinical indications of the patients were recorded by an examination of the hospital system. Images were analyzed by a single radiologist with 8 years of experience. CT images were divided into three groups according to the quality of evaluation as good (optimal), moderate (with artifacts but evaluable) and poor (not evaluable). CT region was divided into six regions (1- brain, 2- thorax, 3- abdominal-pelvis, 4- spinal, 5- extremity, 6- others).

Mobile CT examinations were performed with a 128-slice CT scanner (GE Revolution EVO, GE Medical Systems, Milwaukee, WI, USA). The mobile CT trailer (Figure 1) with all equipment was approximately 14.5 m long, 2.5 m wide, 4 m high and weighs approximately 30 tons. The trailer contained a heated, ventilated and air conditioned, radiation-shielded CT exam room, as well as an operator's area with a workstation, and an electric-operated handicap entrance. The system was directly connected to the field hospital electrical system and equipped with a diesel generator.

Statistical Analysis

All statistical analyses were performed with the Statistical Packages for the Social Sciences (SPSS) version 24 (IBM Corp., Armonk, NY, USA). Descriptive statistics regarding age, gender, clinical indication of CT and other parameters were calculated and are herein presented as numbers and percentages. Continuous data were expressed as mean ± SD (range).

Results

CT imaging of 540 patients was performed over a 26-month period. The mean age of the patients was 25.5 ± 7.3 years (1.0 - 86.0), and approximately 94% were male. The most common clinical indications were trauma (34%) and pneumonia (31%). The demographic characteristics of the patients and clinical indications of CT are presented in Table I. CT image quality was good in 95% of cases. Of 39 patients with moderate and poor CT image quality, 18 had motion artifact, 10 had breathing artifacts, 4 had incorrect contrast phase, 4 had artifact due to foreign body, and field of view was not adjusted correctly in 3 patients. CT imaging of a total of 753 different regions was performed. The most viewed region was the thorax (38%), followed by the brain (23.5%) and abdominal pelvis (22%). Contrast-enhanced CT imaging was performed in 83 patients. The CT image quality and regions are presented in Table II. The most common radiological finding was pneumonia, and it was detected in 40 patients. In 33 of these patients, the findings were typical of viral pneumonia (COVID-19 pneumonia). Bone fracture was seen in 39 patients, and vertebral corpus fracture was present in 7 patients. In addition, ileus (n=4), intestinal perforation (n=2), arachnoid cyst (n=2), aortic aneurysm (n=2), cholelithiasis (n=2), acute hepatitis (n=1), costal fibrous dysplasia (n=1), giant thyroid nodule with retrosternal extension (n=1), sellar mass (n=1), Hill-Sachs lesion (n=1), Kienböck's disease (n=1), ovarian dermoid cyst (n=1), giant ovarian cyst (n=1), and soft plaque with severe stenosis in the popliteal artery (n=1). No finding was detected in 130 (76%) out of 170 patients with clinical indication pneumonia, 140 (75%) of 186 trauma patients, and 38 (56%) of 68 headache patients.

Discussion

During wars, earthquakes and epidemics/pandemics, medical needs are dynamic and change rapidly. The field hospitals providing health care in emergencies must be prepared for these changes and extreme conditions demanded[8]. Field hospitals should consist of equipment suitable for rapid assembly and transportation. This situation is of critical importance for the rapid provision of medical support and the evacuation of the hospital when necessary[5,18]. CT has an important diagnostic role in evaluating trauma and emergency room patients[10]. However, the difficulties in the stability, transportation and installation of the standard CT scanner are significant problems in terms of usability in the field hospital. The mobile CT trailer is a concept that can make transportation easy and ready for use within hours. With its lead-coated surface, it does not require any additional arrangements at the point of protection from radiation. It is ready for use after determining the installation location, transporting it with a truck and deploying it. Thanks to this concept, it is possible to benefit from the advantages of CT in field hospitals.

Figure 1. The mobile CT trailer outside (**a**) and inside (**b**) view.

The nearest equipped hospital to the field hospital was approximately 4 hours away by road and patient transport was ensured by land or air. Three types of costs arise for both modes of transport: fixed (e.g., the cost of land/air vehicle), marginal (e.g., the cost of fuel) and opportunity (unable to use crews/vehicles for other tasks)[19]. The mobile CT trailer is very useful in identifying patients who can be followed or require referral. For example, no pathology was detected in 75% of the patients who underwent imaging due to trauma and were followed up exclusively in the field hospital. Patients with findings, such as intracerebral hemorrhage, pneumothorax-hemothorax and vertebral corpus fracture were referred. Of 36 patients who presented with acute abdominal pain, kidney/ureteral stones were detected, and medical treatment was applied in the field hospital whereas 17 patients with acute appendicitis were referred. The mobile CT trailer facilitated the detection of patients who required to be referred and thus avoided unnecessary costs.

The demand for emergency healthcare services during the COVID-19 pandemic has greatly exceeded hospital capacities in many countries[20]. This emerging challenge has been addressed through the use of field hospitals[20,21]. Such hospitals have played an active role in the diagnosis and follow-up of patients with mild to moderate severity, alleviating the burden of hospitals[21]. The most important imaging modality of COVID-19 infection has undoubtedly been CT[22]. The diagnostic sensitivity of CT in the diagnosis of both disease and complications, in particular in the early phase, has supported the rapid triage of patients[15,21,22]. However, standard CT scanner installation in a stadium, school or open field hospital is a laborious, costly and time-consuming process[21].

Table I. The demographic characteristics of the patients, clinical indications of CT, and CT findings.

Variables (n=540)	
Age, years, mean ± SD (range)	25.5 ± 7.3 (1.0 - 86.0)
Gender, number, female/male	33/507
Clinical indication of CT, number (percentage)	Trauma, n=186 (34%)
	Pneumonia, n=170 (31%)
	Abdominal pain, n=97 (18%)
	Headache, n=68 (13%)
	Others, n=19 (4%)
CT findings	Pneumonia, n=40
	Bone fracture, n=39
	Kidney/Ureter stone, n=36
	Acute sinusitis, n=27
	Acute appendicitis, n=17
	Traumatic/nontraumatic intracerebral hemorrhage, n=7
	Traumatic pneumothorax-hemothorax, n=6
	Others, n=21
	Negative CT findings, n=347

Table II. The CT image quality and regions.

Variables (n=753)	
CT image quality	Good, n=714 (95%)
	Moderate, n=34 (4.5%)
	Poor, n=5 (0.5%)
CT region	Brain, n=177 (23.5%)
	Thorax, n=285 (38%)
	Abdominal-Pelvis, n=167 (22%)
	Spinal, n=69 (9%)
	Extremity, n=45 (6%)
	Others, n=10 (1.5%)

These problems can be eliminated with the mobile CT trailer; in addition, a viewing trailer outside the hospital provides an advantage in terms of reducing the risk of infection transmission. In our center, 33 patients were diagnosed with COVID-19 pneumonia by CT, and early diagnosis and isolation of patients was achieved with the mobile CT trailer. In this way, the CT trailer made an important contribution to preventing the spread of infection in a communal living area.

The image quality of a mobile CT scanner using trauma, operating rooms and intensive care units is lower than that of standard CT[16]. However, no significant difference was found in terms of diagnostic quality[17]. Other disadvantages of the mobile CT are the limited kilovolt, milliampere-second and field of view settings[23]. However, the mobile CT trailer has the same features as standard in-house CT imaging and is able to perform all the tasks of a standard CT scanner. In our study, 95% of the images were of optimal quality.

The mobile CT trailer energy needs were directly provided from the field hospital electrical system; however, generator support is essential as power outages may be more frequent in field conditions. The device's transportation may be a disadvantage, in particular for rural areas where road conditions may be substandard and there might be problems in providing technical support when required. Furthermore, the trailer is made of a durable material, but it may be at risk as a result of direct exposure to outdoor conditions.

Limitations

The most important limitation of this study is that it is based on the experience of the only radiologist working in the field hospital. Evaluation of the data with more observers could provide more objective results. Second, because the field hospital was located in a rural area, therefore the study had a relatively small patient population. In order to evaluate the effectiveness of the mobile CT trailers, studies with a large number of patient populations and in more than one region are needed.

Conclusions

Through our experience of nearly two years in a military field hospital, it was observed that a mobile CT trailer provides convenience in the management of patients, without compromising image quality. The mobile CT trailer can also be used in the event of natural disasters such as earthquakes and epidemics-pandemics, outside military field hospitals. The rapid transportation and installation of the device and the fact that it does not require extra security in terms of radiation, are quite suitable for the conditions of the field hospital. The most important benefit it provides in all these challenging conditions is that it facilitates the identification of patients who require a referral and those that do not. With this study, the effective usability of the mobile CT trailer in emergency situations and areas with limited access has been demonstrated.

Conflict of Interests

The author declares that he has no conflict of interests.

Ethics Approval

This study was conducted after approval in the ethics committee of the University of Turgut Özal (2021/78).

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