European Journal of Radiology 80 (2011) 504–509

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Improving CT scan capabilities with a new trauma workflow concept: Simulation of hospital logistics using different CT scanner scenarios

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ARTICLE INFO

Article history:
Received 21 July 2009
Received in revised form
22 November 2009
Accepted 26 November 2009

Keywords:
Simulation model
CT diagnostics
Trauma resuscitation
Efficiency model
Hospital logistics
Planning

ABSTRACT

Introduction: The Amsterdam Trauma Workflow (ATW) concept includes a sliding gantry CT scanner serving two mirrored (trauma) rooms. In this study, several predefined scenarios with a varying number of CT scanners and CT locations are analyzed to identify the best performing patient flow management strategy from an institutional perspective on process quality.
Materials and methods: A total of six clinically relevant scenarios with variables that included the number of CT scanners, CT scanner location, and different patient categories (regular, urgent, and trauma patients) were evaluated using computer simulation. Each scenario was simulated using institutional data and was assessed for patient waiting times, idle time of CT scanners, and overtime due to scheduling. The best 2- and 3-scanner scenarios were additionally evaluated with the ATW-concept.
Results: Based on institutional data, the best 2-scanner scenario distributes all 3 patient categories over both scanners and plans 4 urgent patients per hour while locating both scanners outside of the trauma room. The best 3-scanner scenario distributes urgent and regular patients over all 3 scanners and trauma patients on only 1 scanner and locates all CT scanners outside of the trauma room. The ATW concept reduces waiting times and overtime, while increasing idle time.
Conclusion: Choosing the optimal planning and distribution strategies depends on the number and location of available CT scanners, along with number of trauma, urgent and regular patients. The Amsterdam Trauma Workflow concept could provide institutions with the ability of early CT scanning in trauma patients without influencing regular and urgent CT scanning.

1. Introduction

The early and accurate diagnosis of injuries is crucial for treating trauma patients, but CT scanning is time-consuming due to technical and logistic reasons [1]. In many trauma centers, the CT scanner is not located in or near the emergency department, but at the radiology department, necessitating patient transfers and in-hospital transports [2]. Consequently, there could be a significant delay in diagnostic information and treatment decisions, possibly with negative health effects.

Several trauma centers have attempted to shorten these delays by moving the CT scanner into the emergency department [3–6] or, in some centers, even into the trauma room itself [7–9]. Although this does bring the CT scanner closer to the patient, most setups still need patient transfers and do require a significant investment [3–6]. In an attempt to improve the early assessment of trauma patients, the Academic Medical Center (AMC) developed the 'Amsterdam Trauma Workflow Concept' (ATW-concept) [8]. Its main feature is the presence of a sliding gantry CT scanner serving two mirrored (trauma) rooms, and a multifunctional patient treatment table, that eliminates patient transfers.

When looking at the individual trauma patient, a reduction of patient transfers following the ATW-concept results in an ear-

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0720-048X/$ – see front matter © 2010 Published by Elsevier Ireland Ltd.
doi:10.1016/j.ejrad.2009.11.026

lier diagnosis and earlier start of treatment [8]. However, the ATW-concept is relatively new and its optimal implementation at a broader patient group level is yet unclear. How should one manage three distinct flows of different patient groups – trauma, urgent (non-trauma), and regular (scheduled outpatients) – at the radiology department given the available CT scanning capacity and CT scanner localizations? Three indicators of process quality can be used to assess the performance of distinct patient flow management strategies following the introduction of the ATW-concept in a hospital: (i) patient waiting time, (ii) the time that the scanner is idle, and (iii) the extra time necessary to ensure that all scheduled patients will be scanned after schedule due to the interruptions of pre-scheduled scans for urgent and regular patients by unscheduled scans for trauma patients (overtime) [3,10–14].

In this study, several predefined scenarios with a varying number of CT scanners and CT locations are analyzed to identify the best performing patient flow management strategy from an institutional perspective on process quality. Additionally, scenarios that will include the ATW-concept will be analyzed to show its effect on process quality as well.

2. Materials and methods

2.1. Patient groups

Three different types of patients were distinguished: trauma, urgent, and regular patients. *Trauma* patients arrive unexpectedly and are in need of immediate care. They usually carry the highest priority upon arrival in the hospital. *Urgent* patients are admitted to one of the hospital wards or the intensive care unit (ICU) and are in need of a CT scan on a particular day, which is usually known at the beginning of that day. *Regular* patients visit the radiology department by prior appointment (scheduled at least 24 h earlier).

2.2. Hospitals, conventional workflow and ATW-concept

Two academic level-1 trauma centers in Amsterdam, the Academic Medical Center (AMC) and the Free University medical center (VUmc), were selected to serve as reference cases and data sources in the scenario analysis of patient flow management strategies. They have three and two CT scanners in use respectively and one of the scanners in the AMC is built according to the ATW-concept.

Prior to 2004, trauma patients in the AMC were evaluated in a trauma room that included a conventional ceiling-mounted X-ray installation. CT scanning was performed at the radiology department, located two floors above the trauma room and accessible by emergency priority elevator. The preparation and transportation of a patient took approximately 7 min on average and a total of six patient transfers [8]. Besides the time-consuming transfers, this conventional workflow also had disadvantageous effects on regular CT planning. The radiology department used a planning schedule for regular and urgent patients during the day-time shift between 8:30 AM and 4:30 PM. Whenever a trauma patient needed CT scanning within this period, regular and urgent patients had to wait and rescheduling was often necessary, resulting in inconveniences for the patients and personnel involved. To minimize overtimes, a limited number of regular scans was planned in anticipation of (unexpected) trauma or urgent patients.

As of 2004, the ATW-concept has been implemented in the AMC. The ATW-concept enables the CT scanner to move between two mirrored trauma rooms (Fig. 1). This concept allows multifunctional usage of one CT scanner. While a trauma patient is being scanned in the main trauma room, another patient can be prepared for scanning in the adjacent (trauma) room. After the scanning procedure in the main trauma room the scanner is immediately slid into the other room and the next patient can be scanned. The ATW-concept ensures the continuous availability of the main trauma room while the trauma room based scanner can still be used for other (trauma, urgent or regular) patients [8].

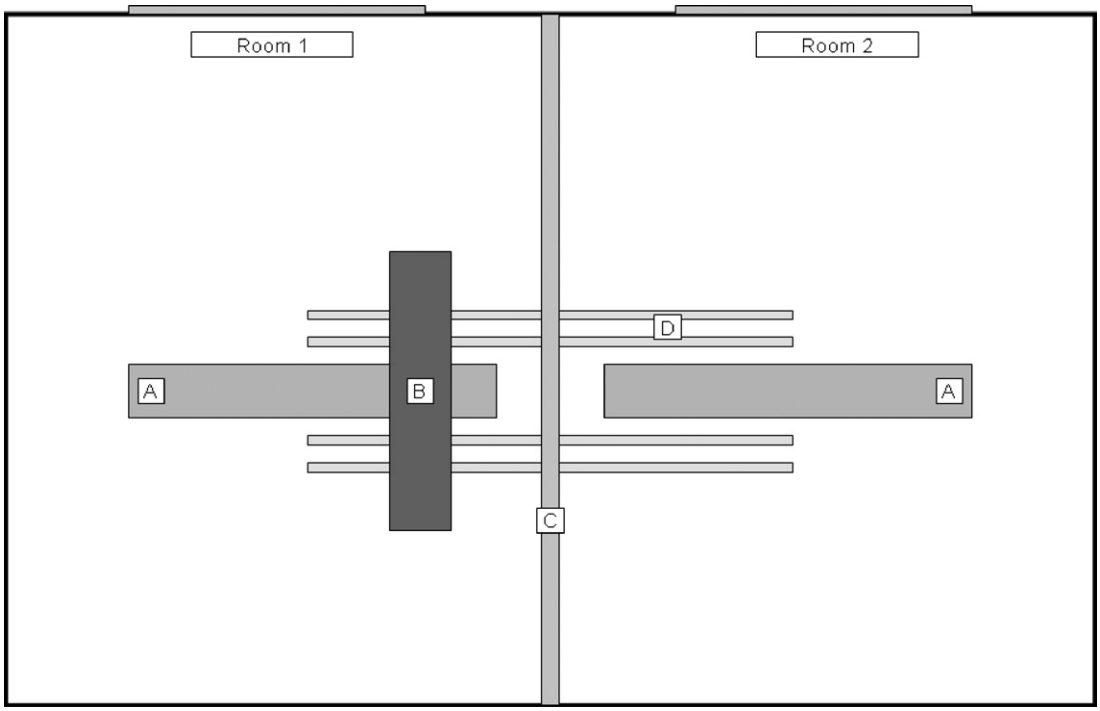

Fig. 1. An overview of the Amsterdam Trauma Workflow concept, with its two adjacent trauma rooms. (A) Patient treatment tables; (B) sliding gantry CT scanner; (C) shielded door separating room 1 and room 2; (D) transporting rails for sliding gantry CT scanner.