International Journal of Surgery 47 (2017) 127–134

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original Research

A nomogram predicting the need for abdominal and pelvic computed tomography in blunt trauma patients: A retrospective cohort study

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HIGHLIGHTS

- Computed tomography (CT) may be helpful in the initial assessment of blunt trauma.
- CT examination has disadvantages, such as radiation exposure, high cost, and time.
- CT scanning should be used selectively to minimize these disadvantages.
- This nomogram can help physicians use abdominal and pelvic CT selectively.

ARTICLE INFO

Article history:
Received 19 June 2017
Received in revised form
20 September 2017
Accepted 22 September 2017
Available online 28 September 2017

Keywords:
Blunt trauma
Computed tomography
Nomogram

ABSTRACT

Background: Abdominal and pelvic computed tomography (APCT) has become the preferred means for the initial evaluation of blunt trauma patients. However, computed tomography examination has some disadvantages, such as radiation exposure, the requirement for intravenous iodinated contrast medium, high cost, and time. We aimed to develop a nomogram to predict the need for APCT scanning after the primary survey of blunt trauma patients.

Materials and methods: We conducted a retrospective observational cohort study at a single-center and reviewed medical records of 972 trauma patients admitted between January 2013 and June 2016. We enrolled 786 blunt trauma patients who had undergone APCT and were 16 years of age or older. A multivariate logistic regression model was used to determine independent predictors for trauma-related findings on APCT scans. A nomogram was constructed to predict injury on APCT scans based on each predictive factor.

Results: Of 786 patients, 355 (45%) patients had at least 1 injury on APCT scans. Results of multivariate logistic regression analysis showed that independent predictive factors of injuries on APCT scans were as follows: falls (≥3 m high); pain (abdominal, back, flank, or pelvic); positive peritoneal signs; abnormal findings on chest radiographs; abnormal findings on pelvic radiographs; and positive findings on focused assessment with ultrasonography for trauma. The nomogram was developed using these parameters. The area under a receiver operating characteristic curve of the multivariate model for discrimination was 0.865 (95% confidence interval, 0.840–0.892). The calibration plot showed good agreement between predicted and observed outcomes. The maximal Youden index was 0.59, corresponding to a cutoff value > 59 points, which was considered the optimal cutoff value for the probability that the injury would be detected on APCT scans.

Conclusion: The nomogram, based on initial clinical findings in blunt trauma patients, will help clinicians be more selective in their use of APCT evaluations.

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https://doi.org/10.1016/j.ijsu.2017.09.063
1743-9191/

1. Introduction

In patients with blunt trauma, evaluating the abdomen and pelvis is a very important part of the initial assessment. Delays in diagnosis are associated with significant morbidity and mortality [1–3]. Because the abdomen and pelvis are notorious sites of occult internal bleeding, even in patients with initially stable hemodynamic parameters [4], diagnosis is difficult, especially in patients with multiple injuries, head trauma, or an altered sensorium from alcohol or drug use.

According to the advanced trauma life support (ATLS) guidelines, abdominal examination is conducted by physical examination, simple radiography, focused assessment with sonography for trauma (FAST), and diagnostic peritoneal lavage [5]. However, computed tomography (CT) scanning provides information relating to specific organ injuries and their extent, and physicians can use it to diagnose retroperitoneal and pelvic organ injuries that are otherwise difficult to assess. Multidetector CT (MDCT) decreases scan times to less than 1 min, and it obtain high quality images of slices thinner than 1 mm [6]. CT has become the preferred means for the initial evaluation of blunt trauma patients because of these benefits [7–9]. Some studies have proposed routine use of CT [9–11]. However, CT examination has some disadvantages, such as radiation exposure, the requirement for intravenous iodinated contrast medium, high cost, and time [12–15]. A previous study suggested that only 10–24% of patients with blunt trauma who underwent CT were found to have an intra-abdominal injury, and it raised concerns about the overutilization of CT [16]. Therefore, whether CT scanning should be performed, and on which patients, is controversial [17–19]. It has also been emphasized that CT scanning should be used selectively to minimize these disadvantages. A few studies have assisted clinicians in determining the need for abdominal CT scanning in blunt trauma patients [20–22]. We hypothesized that a nomogram developed to predict the need for abdominal and pelvic CT (APCT) scanning in patients with blunt trauma after the primary survey would predict positive findings on CT scans.

2. Materials and methods

This study was registered *a priori* with http://www.ResearchResgistry.com/ (*Unique Identifying Number*: *researchregistry3015*). All the design, analysis, interpretation of data, drafting and revisions followed the strengthening the reporting of cohort studies in surgery (STROCSS) guideline [23].

2.1. Study design and data collection

We conducted a retrospective observational cohort study at a single-center in an urban setting in Seoul, South Korea from January 2013 to June 2016. Nine hundred seventy-two trauma patients were admitted to the emergency department during this period. Primary and secondary surveys were conducted on all these patients, according to the ATLS guidelines [5], and APCT scanning was performed on all blunt trauma patients who met the activation criteria of the trauma team (Supplementary file 1), except patients presenting with cardiopulmonary arrest, patients requiring immediate surgery because of unstable vital signs, patients who APCT was deemed unnecessary by the trauma surgeon, and patients who declined APCT. We enrolled 786 blunt trauma patients; they all underwent APCT scanning and were aged 16 years old or older. Patients were divided into 2 groups: the injured group (IG) (n = 355) and non-injured group (NIG) (n = 431) (Fig. 1). The IG group was defined as those for whom trauma-related findings were shown on APCT scans. The groups were compared with respect to clinical and biochemical variables.

The study was approved by the Institutional Review Board of Severance Hospital, Yonsei University Health System (4-2016-1068), which waived the requirement for informed consent because of the retrospective nature of the study.

2.2. Study variables and definition

Baseline characteristics included age, sex, underlying disease, Glasgow coma scale (GCS) score, and trauma-related variables, such as the injury severity score (ISS), revised trauma score, trauma and ISS, and mechanism(s) of injury. Clinical variables, such as vital signs, results of physical examinations, FAST, chest and pelvic radiographic findings, and laboratory variables, such as base excess and lactates levels, were analyzed.

The injuries found on APCT scans were classified and defined as solid organ injury (injury in the liver, spleen, pancreas, adrenal glands, kidneys with urinary tract, and bladder), hemoperitoneum (free fluid in the intra-peritoneal space and retroperitoneal hematoma), intestinal injury (free air, mesenteric contusion or bleeding, and bowel edema or ischemia), and pelvic bone and proximal femur fracture. The torso was defined as the neck, chest, abdomen, and pelvic regions, including the proximal thigh. Lacerations were defined as tears above the subcutaneous layer. Pain reported by patients included pain in the abdomen, back, flank, and pelvis. Peritoneal signs on physical examination by trauma physicians included direct and rebound tenderness in the abdomen. We also assessed “unevaluable conditions,” which we defined as abdominal signs that could not be verified by patients because of low levels of consciousness. Falls from heights of $\geq$3 m were considered high-energy traumas and were included in our trauma team activation criteria. Based on vital signs at the initial assessment in the emergency department, hypotension was defined as systolic blood pressure lower than 90 mmHg. Tachycardia was defined as a heart rate indicating stage 3 or 4 hypovolemic shock. Tachypnea was defined as a respiratory rate more than 20 breaths per minute. Alcohol intoxication was defined as patients in whom ethanol was detected by blood tests. Fractures shown only on chest radiographs included fractures of the sternum, manubrium, clavicle, scapula, rib, and proximal portion of the humerus. Abnormal pelvic radiographic findings were defined as fractures of the pelvic bone, sacrum, lumbar vertebrae, dislocations of the hip and sacroiliac joints, widening of the symphysis pubis, or fractures of the proximal portion of the femur.

2.3. Constructing a model

Univariate logistic regression analysis was used to assess the association between each variable and the injuries visible on APCT scans to select potential predictors. We then used multivariate logistic regression analysis to determine predictive factors using the enter method. Based on the identified predictive factors, a nomogram was drawn for the probability that injuries would be detected by APCT scanning for each variable.

2.4. Evaluating the model's performance

The model's performance was quantified in terms of discrimination and calibration performance. Discrimination was the predictor's ability to separate patients with different responses or events. Calibration was agreement between observed outcome frequencies and predicted probability produced by the model [24].

Discrimination was evaluated using the area under a receiver operating characteristic (ROC) curve. Calibration was evaluated using the Hosmer-Lemeshow goodness of fit test, which compared