Could Full-body Digital X-ray (LODOX-Statscan) Screening in Trauma Challenge Conventional Radiography?

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Background: ATLS Guidelines recommend single plain radiography of the chest and pelvis as part of the primary survey. Such isolated radiographs, usually obtained by bedside machines, can result in limited, low-quality studies that can adversely affect management. A new digital, low-radiation imaging device, the “Lodox Statscan” (LS), provides full-body anterior and lateral views based on enhanced linear slot-scanning technology in just over 5 minutes. We have the first LS in Europe at our facility. The aim of this study was to compare LS with computed tomographic (CT) scanning, as the gold standard, to determine the sensitivity of LS investigation in detecting injuries to the chest, thoracolumbar spine, and pelvis from our own experience, and to compare our findings with those of conventional radiography in the literature.

Methods: We performed a retrospective chart analysis of 245 patients with multiple injuries examined by full-body LS imaging and CT scans between October 1, 2006 and October 1, 2007 at our facility. Patients under the age of 16 years were not included. LS and CT images of chest injuries, injuries to the thoracolumbar spine, and fractures of the pelvis were compared. At our facility, we no longer perform plain radiography for C-spine and head injury, but perform CT scans according to the Canadian rules. Findings with LS were also compared with those reported for conventional radiography in the literature.

Results: Compared with CT scanning, sensitivity and specificity of full-body digital X-ray of blunt chest trauma were 57% and 100%, respectively, thoracic spinal injury 43% and 100%, lumbar spine lesions 74% and 100%, and pelvic injury 72% and 99%. The positive and negative predictive value of LS imaging were 99% and 90% for blunt chest trauma, 100% and 93% for overall spinal injuries, and 90% and 97% for pelvic injuries.

Conclusion: Full-body radiography with LS visualizes skeletal, chest, and pelvic pathologies “all-in-one.” This low-radiation technology detected chest, thoracolumbar spine, and pelvic injuries with an overall sensitivity of 62% and a specificity of 99%. Compared with figures in the literature, LS was more accurate than conventional X-rays. A prospective randomized study is warranted to support these data.

Key Words: Lodox, Trauma, ATLS, Radiography.


The care of the severely injured patient continues to be a challenge for the emergency physician and trauma surgeon. The 7th edition of the ATLS Guidelines (2004) recommends three X-rays as part of the primary survey: cervical spine, thorax, and pelvis. Even though the guidelines leave some room for interpretation, chest and pelvic X-rays are generally thought to be mandatory in patients with multiple injuries.

Such images are obtained by bedside machines, which means that the chest and pelvic X-rays are acquired in only one plane and their value is therefore limited. Inherent delays due to the time-consuming positioning of the portable system close to the patient and the placement of the film, high direct and scattered radiation, and practical difficulties in acquiring satisfactory images can adversely affect management, morbidity, and mortality. Conventional X-rays of the chest and pelvic region are indicated with an overall dose of about 1.587 R (15.87 mGy).

A new digital trauma X-ray device known as the “Lodox Statscan” (LS) (Statscan Critical Imaging System, Lodox Systems [Pty] Ltd, Johannesburg, South Africa) is now available that provides a full-body anterior and lateral view based on enhanced linear slot-scanning technology. The device has an X-ray tube mounted on one end of a C-arm and emits a low-dose collimated fan-beam of X-rays.

A recent study by our group showed that full body a.p. and lateral imaging—the only two images required—require as little as 6.5 minutes for both without moving the patient (Figs. 2 and 3) compared with 25.7 minutes for multiple conventional chest and pelvic X-rays. A special integral docking table in our emergency room next to the standard resuscitation and ventilation equipment receives the incoming trauma patient, thus eliminating the need for transfer to another stretcher.

According to previous studies, the mean conventional dose may be 0.573 R (5.73 mGy), whereas the mean Statscan dose is very much lower, even as low as 0.033 R (0.33 mGy)
The C-arm can rotate around the patient to any angle from 0 to 90 degrees and travels along the table length at up to 138 mm/s (13 seconds for an a.p. view) when emitting radiation.

Because some lesions are difficult to exclude without computed tomography (CT), a CT scan often has to be performed after the secondary survey. In our facility, we no longer perform conventional radiography for C-spine and head injuries and now use CT scans according to the Canadian rules.

With the ATLS approach, patients usually need conventional X-rays as an adjunct to exclude injuries to the chest, spine, or pelvic regions. This is time- and labor-intensive and also radiation-intensive.

The aim of this study was to compare LS with CT scanning, as the gold standard, to determine the sensitivity of LS investigation in detecting injuries to the chest, thoracolumbar spine, and pelvis from our own experience, and to compare our findings with those in the literature.

MATERIALS AND METHODS

We performed a retrospective chart analysis of 245 consecutive patients (Injury Severity Score >16) who underwent LS imaging and full body CT scanning. LS was followed by one craniocaudal spiral CT acquisition which ended at the proximal femur. All CT examinations were performed on a 16-slice multidetector row computed tomography system (Sensation 16, Siemens, Forchheim, Germany) with a collimation of 16 × 1.5 mm and a reconstruction slice thickness of both 2 and 5 mm between October 1, 2006 and October 1, 2007 in our emergency department, a European Level I trauma center. Patient demographics and injury data were taken from our electronic trauma registry. The radiologic endpoint was the preliminary diagnosis summary recorded electronically by the attending emergency physician (unit policy) and the definitive diagnosis of the attending radiologist the following day. Patients younger than 16 years are primarily taken to the children’s hospital trauma unit and were therefore excluded from the present study.

The following diagnoses were compared in LS and CT images: chest injuries with pneumothorax, signs of lung contusion, mediastinal injuries (rupture of the aorta or pneumomediastinum), and thoracic skeletal lesions (fractures of the ribs and clavicles). We also focused on thoracolumbar spine and pelvic lesions involving the acetabulum, pubic bone, sacrum with sacroiliac joint, and the iliac and ischiadic bones. Where possible, the pelvic injuries were classified according to the Tile classification.

Statistical analysis was performed by a consultant statistician for sensitivity, specificity, and positive and negative predictive value, to compare LS versus CT, including 95% confidence intervals for all estimates.

For the purposes of discussion, we also compared our findings with reports in the literature on the sensitivity of conventional radiography in detecting similar injuries, since this technology is used in almost all hospitals for trauma patients.

RESULTS

Two hundred forty-five consecutive trauma patients (172 men and 73 women) aged between 16 and 93 years (mean, 44.5) were included. The mean Injury Severity Score was 20 (range, 16–86). The most common causes of injury were motor vehicle crash (60%), falls from height (20%), and pedestrians hit by motor vehicles (10%).

Chest

CT scans showed pneumothorax in 54 of 245 patients (22%); five patients had to be excluded because they arrived with a chest tube in situ (Table 1). LS detected 26 of the 49 cases (sensitivity: 54%). Of the 23 missed, 7 patients required a chest tube. CT scans showed 60 of 245 patients (24%) with lung contusion, of which 27 were detected by LS. A widened mediastinum was detected by LS in seven patients (sensitivity: 54%) (Fig. 2). Fractured ribs and clavicles were found in 85 of 245 patients (35%) by CT and in 62 by LS. Multiple rib fractures occurred in 50 cases, of which 43 (86%) were correctly diagnosed by LS (Table 2).

Table 1 Comparison of LS and CT in the Detection of Thoracic Injuries

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pleural Injuries</th>
<th>Parenchymal Injuries</th>
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<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>95% CI</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>54</td>
<td>39–69</td>
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<tr>
<td>Specificity (%)</td>
<td>99</td>
<td>97–100</td>
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<tr>
<td>PPV (%)</td>
<td>96</td>
<td>81–100</td>
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<td>NPV (%)</td>
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<td>85–93</td>
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LS, Lodox Statscan; CT, computed tomography; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value.
All major injuries were diagnosed correctly by the initial LS examination, but no life threatening injuries such as unstable burst fractures were missed (Table 3). Further missed diagnoses were stable fractures such as compression fractures of the upper endplate. CT scan showed fractures of the thoracic spine in 44 of 245 patients (18%), of which 19 were found by LS. Of the 25 missed fractures, 6 were instable burst fractures of the upper vertebral bodies which needed stabilization, and 19 were stable fractures mainly of spinous or transverse processes. Fractures of the vertebral bodies and spinous processes were found by CT scan in 35 patients; 18 of these were detected by LS (Fig. 3). CT scan showed lesions of the lumbar spine in 54 of 245 patients (22%), 40 of which were detected by LS.

**Pelvis**

CT examination showed pelvic injuries in 41 of 245 patients (17%). Sixteen of 41 patients (39%) showed stable injuries according to the Tile classification type A, of which nine were detected by LS. Seventeen of 41 patients (41%) with pelvic fractures of Tile type B were found by CT scan (Table 4). LS showed the correct diagnosis in 12 patients. Eight of 41 patients (20%) with rotationally and vertically unstable Tile type C lesions were detected by CT scan and seven by LS.

**DISCUSSION**

Our principal finding was that LS imaging detected chest, thoracolumbar spine, and pelvic injuries with an overall sensitivity of 62% and a specificity of 99.5%. This was achieved with only two full-body images, a lower radiation dose than CT, and in one quarter of the time (6.5 minutes) required for conventional X-rays.

LS imaging showed chest injuries with radiologic signs of lung contusion in 27 of 60 patients (45%). Reports in the literature show a low sensitivity of conventional chest radiography in the detection of lung contusion, ranging from 10% to 69%. Lung contusion becomes evident in chest radiographs in the first 6 to 8 hours after trauma as a nonhomogeneous increase in density which may therefore not be visible during acute management or even the first few days, partly due to accompanying hemothorax or atelectasis. We identified pneumothorax in 26 of 44 cases by LS with a sensitivity of 54%. Previous studies reported a sensitivity...
ranging from 10% to 45% in chest radiographs.\textsuperscript{14,17,18} In cases of small pneumothorax, the air tends to gather in the anterobasal pleural space making diagnosis challenging on conventional X-ray, as in our missed cases. This is of great interest because these undiagnosed injuries can enlarge and become symptomatic or hemodynamically significant if the patient is placed on mechanical ventilation or undergoes general anesthesia\textsuperscript{14,19} as in three of seven patients in our study with missed pneumothorax where chest drainage was required.

A total of 98 patients showed lesions of the thoracolumbar spine. Nineteen of 44 fractures (43%) of the thoracic spine were detected by LS. Seventy four percent of the 54 patients with lesions of the lumbar spine were initially diagnosed correctly by LS imaging. In projections through thick parts of the body, such as the lateral thoracic view, the alignments were clearly visible, but it was difficult in these cases to consistently obtain images with good trabecular details. The morbidity associated with missed spine fractures may be a significant and lifelong problem as it prohibits optimal patient positioning and mobilization, which subsequently contributes to delay in starting ventilation and to the development of pressure ulcers and pneumonia.\textsuperscript{20} Published reports on thoracolumbar spine injury based on plain radiography findings confirmed our findings that posterior element fractures are the most common injuries were 72%, with a good correlation between LS and CT in revealing life-threatening injury of the pelvis in 88% in recognizing significant pelvic fractures has been shown to be as low as 50% to 70%.\textsuperscript{8,23,24}

In our study, the overall sensitivity in detecting pelvic injuries was 72%, with a good correlation between LS and CT of 88% in revealing life-threatening injury of the pelvis in rotationally and vertically unstable lesions of Tile type C. Using LS, the missed Tile type C pelvic lesion appeared to be only a bilateral single ramus pubis fracture. The acute management of this patient was conservative because of the patient’s age of 88 years and other coexisting injuries. Other studies confirmed our findings that posterior element fractures such as sacral or iliac fractures are the most common fractures missed by conventional X-ray\textsuperscript{3,6,22,23} with good sensitivity in anteroinferior parts of the pelvis, such as the pubic symphysis and ramus or ischiadic bone. The sensitivity of pelvic X-ray in recognizing significant pelvic fractures has been shown to be as low as 50% to 70%.\textsuperscript{8,23,24}

We chose a retrospective design for our study as a preliminary investigation. The ideal study design would have been a comparison between conventional X-ray and LS versus CT. The major drawback of such a study would be the exposure of patients to unnecessary radiation, and as such it is not likely that it would be permitted by ethics committees. Nevertheless, an adequately-designed, prospective, randomized study should be performed to evaluate these initial findings.

Because of the number of patients and the complexity of injuries, fast and accurate imaging plays an essential role in triage and evaluation. Many trauma centers have now changed to direct CT imaging, and this negates the need for repeat exposures because of faulty radiology. Although we are presenting an observation and “hands-on” impression rather than a report on a formal study, we think we have shown that this new low-dose technology should be considered during resuscitation. The full-body radiograph may allow CT to be used more selectively and to reduce overall radiation. A weak point seems to be the bad visualization of the cervicothoracic junction.

A further consideration when introducing new technologies is cost-effectiveness. This is an extremely important but complex issue, because not only direct costs (imaging) but indirect costs (reduction of morbidity and mortality, trauma-related aspects) have to be considered. As pioneers in the use of the LS technology in Europe, we think that it is more important at present to communicate our initial results and to reserve the issue of cost-effectiveness issue for future investigations.

It was recently discussed whether the secondary ATLS survey has been superseded because of new imaging technologies because many injuries are now detected before the secondary survey begins.\textsuperscript{25} We conclude that the secondary survey is, however, still essential, but that early scanning makes a valuable contribution to overall clinical evaluation because “clinical suspicions can be immediately correlated with radiologic images so that in large part injuries can be ruled in or out at an early stage.” At our facility, full-body LS imaging proved to be a useful early scanning tool for the rapid detection of critical injuries in trauma patients with a higher accuracy than conventional X-ray compared with figures in the literature. Nevertheless, compared with CT, some noncritical injuries were missed, which supports our conclusion that the secondary survey must still be performed.

**CONCLUSION**

Lodox Statscan imaging as a full-body radiograph with its low radiation visualizes skeletal, chest, and pelvic pathologies “all-in-one” and was more accurate than conventional X-ray, based on figures in the literature. It is a time-saving
independent investigation in emergency department management and only marginally interferes with initial resuscitation.

A prospective randomized study will be useful for the validation of these preliminary findings.

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REFERENCES