The decision to perform computed tomography pulmonary angiography (CTPA) to rule out pulmonary embolism (PE) in orthopedic trauma patients is challenging. The Wells score is a commonly used clinical probability tool developed to determine the likelihood of PE and assist in determining the need for CTPA examination. This study evaluated the usefulness of the Wells score for predicting PE in patients admitted to the orthopedic trauma service.

All patients who were admitted to the orthopedic trauma service at the authors’ institution between 2001 and 2011 who underwent CTPA were identified. The Wells score was calculated retrospectively for each patient, and risk categories using the traditional and alternative interpretations of the Wells score were assigned. Pulmonary embolism was diagnosed in 27 (16%) of 169 patients who underwent CTPA. In total, 27 (0.39%) of 6854 patients admitted to the orthopedic trauma service were diagnosed with PE during initial hospitalization. Mean Wells score was 3.31 (95% confidence interval, ±.28) for the entire population, 3.32 for those without PE (95% confidence interval, ±.31), and 3.28 for those with PE (95% confidence interval, ±.72) (P=.91). Average times from admission to CTPA examination for those with and without PE were 6.18 and 5.7 days, respectively (P=.94).

No significant correlation existed between the Wells score and CTPA results, indicating that the Wells score is limited in predicting PE risk in orthopedic trauma patients.
Orthopedic surgery and traumatic injury substantially increase the risk of pulmonary embolism (PE). The incidence of PE following orthopedic trauma has been reported at rates as high as 27.8%. The risk of developing PE in patients admitted to orthopedic services has been correlated with femoral and tibial plateau fractures, older age, and longer operating times; however, diagnosing PE remains challenging due to its variability in presenting symptoms.

The morbidity and mortality associated with PE is well known, thus highlighting the need for rapid detection and adequate treatment. Computed tomography pulmonary angiography (CTPA) is the most common test ordered by physicians for patients with suspected PE and is considered the current gold standard for diagnosing PE. In orthopedic patients, the increased use of CTPA has not been shown to improve mortality, and it may lead to an ineffective use of resources, increased exposure to ionizing radiation, contrast dye, and unnecessary anticoagulant use. Significant concern exists among orthopedic surgeons and the larger medical community concerning CTPA’s effectiveness in detecting clinically significant PE.

The improvement in CTPA technology has enhanced the detection of pulmonary microemboli; however, the clinical significance of these smaller emboli is unknown. Along with the poorly defined risk of improved detection, CTPA is unable to differentiate acute from past PE events or reliably delineate pathologic risk from the normal physiologic processing of lung clots. Currently, the increased ability to detect small pulmonary emboli on CTPA leads to an obligation for treatment; an adequate model of risk stratification that can limit the number of potentially unnecessary CTPA examinations being performed is needed.

The evaluation of patients’ embolic risk has led to the development of several screening and diagnostic methods that aid in the early detection and treatment of PE. The most commonly used tests include the Wells score, Geneva score, Miniati score, and Charlotte rule, of which the Wells score is the most widely used and accepted. Two variations exist: the traditional and alternative Wells scores (Table 1). The alternative Wells score was created to simplify the scoring system to increase its clinical usefulness. To the current authors’ knowledge, the usefulness of the Wells score for predicting the likelihood of PE in orthopedic trauma patients has not been reported. The goal of this study was to evaluate the ability of the Wells score to accurately predict CTPA need for the confirmation of clinically suspected PE in patients admitted to the orthopedic trauma service.

**MATERIALS AND METHODS**

This study was conducted at a single Level I trauma center following institutional review board approval. All patients admitted to the orthopedic trauma service at the authors’ institution between 2001 and 2011 were retrospectively identified (N=6854). Patients who underwent CTPA for suspected PE were selected for further investigation. Patients in the orthopedic trauma service had standardized thromboembolic prophylaxis using thromboembolic deterrent stockings, sequential compression devices, and early mobilization. In addition, routine heparin or enoxaparin use was initiated on postoperative day 1, except when contraindicated. Patients with lower-extremity trauma precluding the use of thromboembolic deterrent stockings, sequential compression devices, or both were treated with early mobilization and chemical anticoagulation.

Computed tomography pulmonary angiography was performed on 16- and 64-MDCT scanners (Siemens AG [Erlanger, Bavaria, Germany] and GE Healthcare [Little Chalfont, Buckinghamshire, United Kingdom]). A 100-mL bolus of contrast medium (Iopamidol: Isovue 370; Bristol-Myers Squibb, New York, New York) was administered intravenously.
at 4 mL per second, with a 22-second delay. Caudocranial helical images were acquired from the thoracic inlet to the adrenal glands at 120 kV, with axial and coronal reconstructions available for review. Fellowship-trained, board-certified radiologists interpreted the CTPA images. The diagnosis of PE was based on final CTPA reports and classified as positive or negative.

A blinded reviewer (M.D.Y.) calculated a Wells score for each patient based on a retrospective chart review of clinical symptoms and patient history factors. The reason for ordering the CTPA examination was recorded and compared between patients with and without PE to assess whether each was predictive for PE (Pearson chi-square test). Risk categories using the traditional and alternative interpretations of the Wells score were evaluated for effectiveness in predicting PE by comparing the risk category for patients determined to be positive or negative for PE (Pearson chi-square test). Mean Wells score for patients positive and negative for PE were also compared without consideration for the risk category (2-sample t test).

The billing cost of total hospitalization and the specific billing cost of the CTPA examination, as billed by the institution, were recorded and compared between patients with and without PE (2-sample t test). Statistical significance was set at a P value less than .05 for all statistical analyses.

**RESULTS**

Over the 10-year study period, 6854 patients were admitted to the orthopedic trauma service; 169 (2.74%) of these patients underwent CTPA for clinical suspicion of PE. Sixteen percent (27 of 169) of patients undergoing CTPA examination had a positive PE diagnosis. The overall PE prevalence was 0.41% (27 of 6854).

Of the 27 patients, 19 were men and 8 were women with mean ages of 49±7 and 51±8 years, respectively. No statistical difference existed in sex or age for those with and without PE (P > .197). Average time between admission and CTPA examination was not statistically different between patients with negative and positive CTPA studies (6.18 days [95% confidence interval (CI), ±1.22 days]) and 5.7 days (95% CI, 5.7±2.17 days), respectively (P = .601).
Among the patients undergoing CTPA, the most common comorbidity was hypertension (41.4%; 70 of 169), and the most common presenting injury was a hip or acetabular fracture (59.1%; 100 of 169). Comorbidity data are presented in Figure 1, and the presenting injury data are presented in Figure 2.

Using the traditional Wells score, 37.9% (64 of 169) of patients were categorized as low risk, with 15.6% (10 of 64) having positive CTPA studies. One hundred one (59.8%) of 169 were considered at intermediate risk, with 16 (15.8%) patients positive for PE; 4 (2.36%) patients were considered high risk, with 1 (25%) patient having a positive CTPA. The traditional Wells scoring system was not significantly predictive of positive PE on CTPA ($P = .726$) (Table 2).

Using the alternative Wells score, 66.9% (113 of 169) patients were considered PE unlikely, with 15.9% (18 of 113) of these having positive CTPA studies. The remaining 33.1% (5 of 169) of patients were considered PE likely, and 9 (16.1%) of 56 patients were positive for PE. No significant predictive relationship existed between the alternative Wells score and PE diagnosis ($P = .601$) (Table 2). The reason for ordering CTPA was not significantly predictive of a positive CTPA scan ($P > .21$) (Figure 3).

Mean billing cost for the CTPA examination was $2158, whereas mean total billing cost of hospitalization was $99,190 and was not statistically different between patients with and without PE ($P = .91$).

**DISCUSSION**

This study examined the usefulness of the Wells score for predicting PE in more than 6000 patients who were admitted to the orthopedic trauma service between 2001 and 2011. The Wells score was not significantly predictive of PE in patients admitted to the orthopedic trauma service.27

It is widely accepted that the Wells score has predictive value in determining PE risk in hospitalized patients,23,24,26-28 but its efficacy in trauma and other patient populations has recently been questioned.25,29-32 The limitations of the Wells score have been described and are likely based on the demographics of its design cohort, along with its susceptibility to physician subjectivity concerning the Wells criterion of most likely diagnosis.18,9,33-35 The PIOPED trial was a large validating study of the Wells score in medical patients.21 However, compared with this patient population, the current study found less Wells score variability in orthopedic trauma patients ($P > .21$), suggesting a lack of applicability of the scor-
An effective clinical risk stratification tool is essential for efficient CTPA use. Other studies examining nontrauma patients have used combinations of the Wells score with ventilation and perfusion scans, electrocardiogram, arteriole blood gas, and D-dimer assay. In association with the Wells score, D-dimer has been shown to exclude PE in low-risk populations with more than 97% certainty. However, due to the nature of trauma patients, D-dimer is frequently elevated and, thus, likely to be less effective in evaluating PE risk.

The current study had several possible limitations. First, if patient history and symptoms were not accurately recorded, the Wells score accuracy may have been affected. In addition, although the clinical data for the 169 patients undergoing CTPA were evaluated, no clinical data on the remaining patients in the cohort were evaluated. An evaluation of these other patients may have provided a more comprehensive picture of the patient population admitted to the orthopedic trauma service. In addition, this patient cohort was an inherently high-risk population, with few patients in the population falling in low-risk or unlikely PE categories due to being assigned a minimum of 1.5 points on the Wells score for their postoperative status. Because of this, the Wells score may not be an optimal pretest scoring system in specialties treating mainly posttraumatic and postoperative patients. Lastly, a single, blinded reviewer assigned Wells scores; however, the Wells score has good inter-rater reliability.

CONCLUSION

Postoperative PE is a major clinical postoperative concern in orthopedic trauma patients and has led to an increased use of CTPA as a screening tool. The decision to perform CTPA when investigating PE in patients admitted to the orthopedic trauma service should be considered carefully to avoid unnecessary additional costs and exposures to ionizing radiation, contrast dye, and anticoagulant therapy. With the goal of evaluating effective CTPA use, this study examined the usefulness of the Wells score for predicting PE in orthopedic trauma patients and found no significant correlation between the two. Further study is needed to develop a predictive scoring system that effectively assesses PE risk and delineates the need for diagnostic CTPA in orthopedic trauma patients.

REFERENCES


