Detection of Pulmonary Embolism in the Postoperative Orthopedic Patient Using Spiral CT Scans

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Abstract Orthopedic surgery is associated with a significant risk of postoperative pulmonary embolism (PE) and/or deep vein thrombosis (DVT). This study was performed to compare the clinical presentations of a suspected versus a documented PE/DVT and to determine the actual incidence of PE/DVT in the post-operative orthopedic patient in whom CT was ordered. All 695 patients at our institution who had a postoperative spiral CT to rule out PE/DVT from March 2004 to February 2006 were evaluated and information regarding their surgical procedure, risk factors, presenting symptoms, location of PE/DVT, and anticoagulation were assessed. Statistical analysis was performed using an independent samples *t* test with a two-tailed *p* value to examine significant associations between the patient variables and CT scans positive for PE. Logistic regression models were used to determine which variables appeared to

be significant predictors of a positive chest CT. Of 32,854 patients admitted for same day surgery across all services, 695 (2.1%) had a postoperative spiral CT based on specific clinical guidelines. The incidence of a positive scan was 27.8% (193/695). Of these, 155 (22.3%) scans were positive for PE only, 24 (3.5%) for PE and DVT, and 14 (2.0%) for DVT only. The most common presenting symptoms were tachycardia (56%, 393/695), low oxygen saturation (48%, 336/695), and shortness of breath (19.6%, 136/695). Symptoms significantly associated with DVT were syncope and chest pain. A past medical history of PE/DVT was the only significant predictor of a positive scan. Patients who have a history of thromboembolic disease should be carefully monitored in the postoperative setting.

Keywords spiral CT · orthopedic surgery · thromboembolic complications

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Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

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Introduction

Orthopedic surgery patients are at a high risk for thromboembolic complications including deep vein thrombosis (DVT), pulmonary embolism (PE), and, as a consequence, death. Hip and knee arthroplasty traditionally carry the highest risk of thromboembolic disease of all orthopedic procedures. The incidence of DVT in patients without prophylaxis is 40–84% for total knee replacement [1] and 39–74% for total hip replacement [2]. The incidence of fatal PE following total joint replacement has ranged from 0.19% to 3.4% [2–4], and the incidence of asymptomatic PE has been reported to be as high as 12% [1]. Trauma patients also have notoriously high rates of DVT, although these clots are often detected prior to any fracture fixation procedures. Geerts et al. [5] found a 69% rate of DVT in patients with lower extremity fractures, a 62% rate in patients with spine fractures, and a 54% rate of DVT in patients with major head injuries. Research has shown that

the rate of DVT in spine surgery patients ranges from 0.8% to 15.5% [6–9]. A recent study found an incidence of DVT of 0.5% and an incidence of PE of 0.23% in total shoulder arthroplasty patients [10]. The rate of DVT following foot and ankle procedures is typically between 0.2% and 3.5%, and the rate of symptomatic PE is even lower, ranging from 0% to 0.2% [11–12].

Because clinical presentation is unreliable for diagnosis of thromboembolic complications, imaging modalities have become the most effective way to diagnose PE. In the past, ventilation–perfusion (VQ) scans were used to determine the probability of PE. The VQ lung scan involves the inhalation of xenon gas and is advantageous because of low radiation exposure to the patient undergoing the exam (<2.5 mSv) and relatively low cost when compared to spiral CT. However, VQ scans have serious limitations as the results are based on the indirect visualization of the clot, and diagnosis is, therefore, restricted to “high, intermediate, or low probability”. The study also takes approximately 1 h to complete. Spiral CT is currently the most popular test to aid in the diagnosis of pulmonary emboli [13] as it provides high specificity (81% to 100%) with direct visualization of the pulmonary vasculature, can reliably detect compounding or additional pulmonary conditions, and can be completed in less than 30 s. Reports validating the clinical significance of this sensitive and specific imaging for PE/DVT and identifying the potential for identifying clinically insignificant PE do not currently exist.

The symptoms of PE can range from nonexistent to mild to severe and are strongly related to a patient’s underlying pulmonary reserve [14–16]. Pulmonary emboli pose a diagnostic challenge because of their lack of consistent, specific presentation. The goal of this study was to determine the overall incidence of positive spiral CT scans in a postoperative orthopedic surgical patient population who underwent the scans for suspected PE/DVT and to determine the relationship between the type of procedure and a positive scan. Another aim was to determine which symptoms were associated with positive spiral CT scans in this patient population. The final goal was to determine which risk factors were associated with a positive spiral CT scan in this patient population.

Materials and methods

All orthopedic surgery patients who underwent spiral CT scans of the chest, pelvis, or lower extremities at our institution during the 2-year period from March 2004 to February 2006 were screened for inclusion. Of these 771 patients, 76 were excluded immediately because they were non-surgical patients (43), had medical records that were missing documentation of the scan (18), or had preoperative instead of postoperative scans (15). After this initial review, there were 695 patients who had the designated spiral CT scans following an orthopedic surgical procedure and were included in this retrospective case series.

The hospital medical records and spiral CT scan reports of these 695 patients were reviewed to collect demographic

and surgical data. Risk factors for the development of PE were defined as including a history of previous PE or DVT, smoking, current hormone replacement therapy or oral contraceptives, and current malignancy. The clinical signs, symptoms and abnormal test results which prompted the ordering of the scans were noted. The anticoagulation prophylaxis, size and location of identified PEs, and treatment of PE and/or DVT in patients with positive scans were also recorded. The spiral CT scans included the chest, pelvis, and lower extremities, so only DVT proximal to the popliteal vein was detected and recorded.

The location of the PE/DVT was stratified into left and/or right main, lobar, segmental, and subsegmental arteries and peripherally into pelvic and lower extremity clots. Only the largest vessel order clot was noted for each side.

All of the hip, knee, shoulder, trauma, and spine patients had pneumatic compression sleeves placed. All patients undergoing total hip and total knee replacement also received pharmacological anti-coagulation with warfarin, low-molecular-weight heparin, or aspirin in accordance with the standard protocol for DVT prophylaxis at our institution. Arthroscopy, foot, ankle, and hand patients were not given anticoagulation therapy.

Statistical analysis was performed by a medical statistician using an independent samples *t* test with a two-tailed *p* value. Significance was defined as a *p* value less than 0.05. Logistic regression models were used to determine which variables appeared to be significant predictors of a positive chest CT in this patient population.

Results

One hundred ninety-three of the 695 scans were interpreted as indicating the presence of DVT and PE. The overall incidence of PE/DVT was 27.8% (193/695). One hundred fifty-five scans (22.3%) were positive for PE only, 24 (3.5%) for PE and proximal DVT, and 14 (2.0%) for proximal DVT only. A total of 179 patients had a scan positive for PE, comprising 0.5% of the total surgical population (155/32,854). The location of the identified PE and/or DVT was as follows: 3 main-single, 7 main-multiple, 28 lobar-single, 42 lobar-multiple, 29 segmental-single, 35 segmental-multiple, 30 subsegmental-single, 24 subsegmental-multiple, 15 pelvic clots, and 26 lower extremity clots.

Total joint arthroplasty and spine procedures were observed to have the highest incidence of positive scans in this sample of patients that underwent scans for suspected PE/DVT. The incidence of positive findings for total shoulder arthroplasty was 8 of 11 or 72%, for total knee arthroplasty 84 of 244 or 34.4%, for total hip arthroplasty 52 of 188 or 27.7%, for revision total knee arthroplasty 8 of 29 or 27.6%, and for spine procedures 33 of 136 or 24.3%. The highest incidence of positive scans for PE only were in total shoulder arthroplasty (63.6%, 7/11), primary total knee arthroplasty (32.4%, 79/244), primary total hip arthroplasty (25%, 47/188), and spine patients (22.8%, 31/136).

The symptoms that prompted the ordering of a scan included tachycardia, fever, syncope, chest pain, shortness

of breath, low oxygen saturation defined as $<90\%$ on pulse oximetry, atrial fibrillation, confusion, nausea, and dizziness. Tachycardia (54.4%, 105/193), low oxygen saturation (49.7%, 96/193), and shortness of breath (23.3%, 45/193) were the symptoms most commonly associated with positive scans. Atrial fibrillation ($p=0.057$, 15/78, 19.2%), confusion ($p=0.058$, 5/35, 14.3%), and nausea ($p=0.075$, 13/14, 92.9%) were not predictive of a positive scan. Patients with low oxygen saturation were significantly ($p=0.0001$) more likely to have scans positive for PE. Using a logistic regression model, oxygen saturation ($p=0.003$) and a history of PE/DVT ($p=0.008$) were found to be significant predictors of PE. Atrial fibrillation and estrogen use were not significant predictors ($p=0.09$).

Of the risk factors analyzed as predictive of a positive scan, a history of PE and/or DVT was significantly associated with a scan positive for PE ($p=0.004$, 21/48, 43.8%). In addition, patients with a higher BMI (BMI >30) were more likely to have scans positive for PE ($p=0.048$, mean 28.98 negative vs. mean 30.10 positive) than those with a lower BMI. When patient demographic variables were entered into a logistic regression model, a history of previous PE/DVT was found to be a significant predictor ($p=0.006$) of having a positive scan for PE, while BMI and estrogen use were found to be marginally significant predictors ($p=0.06$ and $p=0.07$, respectively). The odds of having a positive chest CT scan were 2.3 times higher if patients had a history of PE/DVT than if they did not (95% CI, 1.3–4.3). Smoking was not found to be a positive predictor of a positive scan. There was no detectable relationship between patient risk factors or presenting symptoms with respect to the detection of proximal (pelvic) DVTs. Syncope and age were found to have a trend towards significance with pelvic clots ($p=0.075$, $p=0.103$). Positive lower extremity CT scans were significantly related to previous PE/DVT ($p=0.03$, 5/48, 10.4%), syncope ($p=0.005$, 4/20, 20%), and chest pain ($p=0.04$, 8/109, 7.3%).

Discussion

The purpose of the study was to examine those postoperative orthopedic surgical patients with documented positive spiral CT for detecting PE/DVT as related to the clinical symptoms at presentation, medical history, and risk factors. We hoped to use this information to determine appropriate and optimal utilization of this sensitive but costly diagnostic imaging evaluation, which exposes patients to both ionizing radiation and potential contrast reaction.

In our study, patients with low oxygen saturation were significantly more likely to have a spiral CT scan positive for PE than those with normal saturation values. In addition, when all risk factors were considered (previous history of PE or DVT, smoking, current hormone replacement therapy or oral contraceptive use, and current malignancy), patients with a history of prior DVT and/or PE were more likely to have a positive CT scan, which suggests that a patient's propensity for developing DVT and/or PE may depend on

individual factors (i.e., variation in coagulation factors, genetics, etc.).

Parvizi et al. [18] suggested that sensitive imaging studies like spiral CT result in an increase in detection of pulmonary emboli and may lead to the unnecessary treatment of single, isolated subsegmental clots. Over the 5-year study period, the incidence of PE increased from 0.21% with VQ scans to 0.98% with spiral CT without changes in mortality rates [18]. The patients whose clots were not detected with the less sensitive VQ scans did not seem to suffer a greater risk of death and were spared the risk of complications associated with the prolonged anticoagulation therapy which is the accepted treatment for pulmonary emboli. Furthermore, as the technology continues to improve, the resolution and ability to observe smaller subsegmental PE will undoubtedly increase along with the required anticoagulation. Further research is needed to determine the risk/benefit profile for the treatment of small and/or isolated subsegmental clots and determine if patients diagnosed with only small tertiary pulmonary emboli would benefit from not being treated. In our study, the overall incidence of detected PE was approximately 0.5%, which is an incidence consistent with that reported in the literature [2–4].

Because of the low overall incidence of PE [1–4], it is unreasonable to perform postoperative CT scans on all orthopedic patients or even all patients who have undergone higher risk procedures like total joint arthroplasty. Such an approach would increase the risk of unnecessary radiation exposure to patients and would be imprudent from a cost–benefit analysis of health care. In the outpatient setting, D-dimer measurement may be useful in stratifying patients into groups with high or low suspicion of venous thromboembolism [17]; however, D-dimers are almost universally positive in the postoperative setting and are therefore unhelpful in this setting [19].

In our study, total joint arthroplasty and spine procedures were observed to have the highest incidence of positive scans. Common symptoms at presentation prompting a scan to rule out PE were tachycardia, shortness of breath, and a low O_2 saturation ($<90\%$), and although not all of these symptoms were positive predictors of a scan, it is possible that a combination of symptoms with certain demographics can lead to highly specific presentations for PE. When analyzing risk factors, a past medical history of PE/DVT and BMI >30 were significantly associated with a positive scan. Larger clinical trials need to be done to integrate sensitive and specific risk factors for deterring life-threatening PE/DVT with clinical presentation in order to develop the most appropriate algorithm for ordering a spiral CT to rule out PE/DVT in the postoperative orthopedic setting.

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