Thromboembolic Complications Following Spine Surgery Assessed with Spiral CT Scans

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Abstract Spine surgery is associated with a significant risk of postoperative pulmonary embolism (PE) and/or deep vein thrombosis (DVT). The goal of this study was to determine which symptoms and risk factors were associated with spiral CT scans positive for PE and/or DVT in the postoperative spine surgery patient. We conducted a retrospective review of all spine patients who underwent a postoperative CT to rule out PE during the period of March 2004–February 2006. The type of surgical procedure, risk factors, symptoms prompting scan ordering, anticoagulation, and treatment were recorded. Logistic regression models were used to determine significant predictors of a positive CT in this patient population. Of the 3,331 patients that had spine surgery during the study period, 130 (3.9%) had a spiral CT scan to rule out PE and/or proximal DVT. Thirty-three of the 130 (25.4%) CT scans were positive for PE only, five (3.8%) for PE and DVT, and three (2.3%) for DVT

only. Only 24.5% (32) patients had risk factors for thromboembolic disease, and of these, a history of PE and/or DVT was the only significant risk factor for a positive scan ($p=0.03$). No presenting symptoms or demographic variables were noted to have a significant association with PE and/or DVT. The type of surgical procedure (i.e., anterior, posterior, and percutaneous) was not associated with an increased risk for PE and/or DVT. Patients who are undergoing spine surgery with a history of thromboembolic disease should be carefully monitored postoperatively and may benefit from more aggressive prophylaxis.

Keywords spine surgery · spiral CT · thromboembolism

Introduction

Virchow's triad identifies three factors which predispose a patient to thromboembolic disease: venous stasis, vascular injury, and hypercoagulable state. It is no surprise then that orthopedic procedures pre-dispose a patient to thromboembolic complications because they entail surgery in close proximity to neurovascular structures as well as a period of recovery postoperatively when the patient is relatively immobilized. Traditionally, hip and knee replacement literature has focused extensively on deep vein thrombosis (DVT) prophylaxis, and it is now routine practice to ensure these patients are on mechanical as well as pharmacological DVT prophylaxis postoperatively [9, 21].

Spine surgery can involve long periods of postoperative immobilization, posing a high risk for DVT and/or pulmonary embolism (PE). In addition, anterior approaches for circumferential fusion often involve manipulation of the inferior vena cava, which can subsequently lead to transient vascular injury and relative venous stasis, increasing the risk of developing thromboembolic complications. Other risk factors such as smoking, current hormone replacement therapy or oral contraceptives, and current malignancy can further predispose spine surgery patients to thromboembolic complications. The literature on the incidence of thromboembolic complications in the spine patient is sparse, but some studies estimate the incidence of DVT to be as high as 15% and PE to be 0.5–2.7% in patients on mechanical

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Level of evidence: Level IV Prognostic Study

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prophylaxis [2]. In immobilized patients with spine fractures or head injuries without any prophylaxis, the rate of DVT has been quoted to be as high as 62% [10, 11]. These numbers are alarming because, though they are as high as those for patients undergoing hip or knee arthroplasty, the majority of spine patients only receive mechanical DVT prophylaxis with compression stockings. The approach to prophylaxis in spine patients has been more judicious compared to their arthroplasty counterparts because of the associated hemorrhagic complications associated with chemical prophylaxis in this patient population [3, 13, 18, 20]. Nonetheless, in high-risk patients, a combination of mechanical and chemical prophylaxis is anecdotally recommended along with the prophylactic use of an IVC filter in select patients.

Pulmonary emboli pose a diagnostic challenge because of their lack of consistent, specific presentation. Symptoms of PE can range from nonexistent to mild to severe and are strongly related to a patient's underlying pulmonary reserve [16]. Research has shown that asymptomatic PE is alarmingly common with an incidence of up to 12% [14]. When symptoms are present, tachycardia, fever, and shortness of breath are common but insensitive and nonspecific for PE [16, 19]. Patients' symptoms can vary based on their cardiopulmonary reserve, pain tolerance, or other factors in their medical history, size of the clot, and the presence or absence of pulmonary infarction, which may influence clinical presentation.

Because clinical presentation is unreliable for diagnosis, imaging modalities have become the most effective way to diagnose PE. In the past, ventilation–perfusion (VQ) scans were used to detect PE. This type of scan involves the inhalation of Xenon gas and is advantageous because of low radiation levels (<2.5 mSv) and relatively low cost when compared to spiral CT. However, VQ scan has serious limitations such as indirect visualization of the clot and results restricted to “high, intermediate, or low probability.” Spiral CT is now considered the gold standard for diagnosing pulmonary emboli because these scans allow for direct visualization of the pulmonary vasculature, are able to reliably detect alternative or additional conditions, have a high specificity (81% to 100%), and can be completed in less than 30 s [12].

The primary goal of this study was to determine the overall incidence of positive spiral CT scans in patients suspected of suffering PE after spinal surgery. Additionally, we aimed to determine which symptoms and risk factors were associated with positive scans. Finally, we aimed to determine if the surgical approach could be shown to correlate with risk of postoperative PE. This information can be used to better establish valid guidelines and better determine the appropriate algorithm for ordering spiral CT scans in this patient population.

Materials and methods

We conducted a retrospective review of all spine patients at our institution and identified those patients who underwent

a postoperative spiral CT scan to rule out PE and/or DVT from March 2004 to February 2006. The type of surgical procedure, risk factors, symptoms prompting the ordering of the CT scan, and prophylactic anticoagulation administered were recorded.

During the study period, 3,331 patients underwent spine surgery at our institution, 136 of whom had spiral CT scans to rule out PE and/or proximal DVT. Of these 136 patients, three were excluded immediately because the patients had multiple spine surgeries and spiral CT scans positive only during one admission which was outside of the study time period. Another two were excluded because medical records were missing documentation of the scan, and one more patient was excluded because the patient had a preoperative instead of postoperative scan. After this initial review, 130 spine patients who had spiral CT scans following a surgical procedure on the spine were identified and included in the study.

In this retrospective, observational study, the hospital medical records and spiral CT scan reports of these 130 patients were reviewed to collect demographic and surgical data, risk factors for PE (history of previous PE or DVT, smoking, current hormone replacement therapy or oral contraceptives, and current malignancy), symptoms and tests which prompted the ordering of the scan, anticoagulation regimen, and size, location, and treatment of PE and/or DVT in patients with positive scans. The spiral CT scans included the chest, pelvis, and lower extremities so only DVT proximal to the popliteal vein was detected and noted. All of the spine patients had pneumatic compression sleeves (VenaFlow®, Aircast® Inc.) placed as routine admitted inpatient care, and three patients had prophylactic IVC filter placement preoperatively. None of the patients received chemical DVT prophylaxis.

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

Thirty-three of the 130 CT scans were positive for PE only (25.4%), five patients had a PE and DVT (3.8%), and three patients had a DVT only (2.3%). The overall incidence of scans positive for PE only was 1% (33 positive scans of 3,331 patients who underwent spine surgery).

Thirty-two of the 130 patients scanned (24.5%) had at least one risk factor for thromboembolic disease. Eight of the 130 scanned patients (6.2%) had a history of previous DVT/PE, 19 (14.6%) were smokers, four (3.1%) were on estrogen or oral contraceptives, and two (1.5%) had cancer. A history of PE and/or DVT was the only significant risk factor associated with a positive scan (*p*=0.03) in those patients actually scanned.

Several postoperative symptoms prompted ordering of scans to assess for the presence of PE/DVT. Forty-eight

percent (63/130) of the scanned patients presented with tachycardia, 24.1% (31/130) with chest pain, 20% (26/130) with shortness of breath, and 15% (19/130) with fever over 38.5°C. Cardiac arrhythmia and syncope were less common presentations, with nine patients experiencing cardiac arrhythmia (6.9%) and four patients experiencing syncope (3.1%). None of the symptoms had a significant association with a positive scan for PE and/or DVT.

The surgical approach was not a factor predictive of a positive CT scan in this patient series. Assessment of the performed surgical procedures indicated that 87 patients underwent posterior approach spine surgery, 17 underwent anterior approach spine surgery, 20 underwent combined anterior and posterior approaches, and six underwent percutaneous approaches (i.e., kyphoplasty). A total of 37 anterior approaches were performed either in isolation or in combination anterior/posterior surgeries in our statistical analysis. The type of surgical approach (i.e., anterior, posterior, and percutaneous) was not associated with an increased risk for PE and/or DVT.

Discussion

Pulmonary embolism can be a diagnostic challenge because of its often ambiguous presentation [16]. The goal of this study was to determine the incidence of positive spiral CT scans in the postoperative spine surgery patient population and determine what symptoms, risk factors, and surgical approaches are associated with a positive scan. In our study, there was no significant association between any of the symptomatic presentations assessed and the likelihood of having a positive CT for PE and/or DVT. However, tachycardia, shortness of breath, and pleuritic chest pain were the most common presentations. Logistic regression models to examine these combinations of symptoms as well as combinations of others have failed to show significant predictors from symptomatology to the likelihood of having a positive scan for PE.

One limitation of this study is that only patients with certain symptoms were given a postoperative spiral CT scan. Therefore, our overall PE incidence of 1% does not include any asymptomatic PEs that went undetected and therefore cannot be reported as the true incidence. If our purpose of this paper was to examine all those patients who have had spine surgery and report a true incidence, it would involve significant numbers of CT scans which would not be feasible from an economic perspective. If this path was chosen, however, a power analysis would have been performed in order to have a better estimate of the number of patients we needed in the study to have significant findings. The goal of this study was to report associations between patient presentation and positive CT scans in an economically feasible way. The reported prevalence of different symptoms for patients with positive PE on CT scan is data which can aid in a power analysis for future studies. Another weakness of this study is the variability in the threshold for ordering a spiral CT scan at each institution and even within a given institution, which results

in a selection bias in retrospective studies such as this. Our institution has specific guidelines for ordering a spiral CT scan and each scan must be approved by an internist who has personally evaluated the patient. Thus, we have done our best to standardize the ordering of spiral CT scans at our institution.

Parvizi et al. suggests 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 [17]. Over the 5-year study period, the incidence of pulmonary embolism increased almost five-fold from 0.21% with VQ scans to 0.98% with spiral CT, but mortality rates did not increase concomitantly [17]. The patients whose clots were not detected with the less sensitive VQ scans did not seem to suffer a greater risk of death, and they were spared the risk of complications associated with the prolonged anticoagulation therapy that is the accepted treatment for pulmonary emboli. As the technology continues to improve, the resolution and ability to observe smaller subsegmental PE will undoubtedly increase along with the use of potent anticoagulation. Further research is needed to determine the risk/benefit profile for the treatment of small and/or isolated subsegmental clots and decide if patients diagnosed with only small pulmonary emboli benefit without treatment for risks of bleeding.

All of the risk factors considered (previous history of PE or DVT, smoking, current hormone replacement therapy or oral contraceptive use, and current malignancy) have been associated with DVT or PE in the medical literature. In our study, 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.) that predispose those patients to developing a clot. A risk factor such as this can be a diagnostic tool for the physician in identifying patients that have thromboembolic complications.

Attention has also been focused on trying to associate surgical approaches with the likelihood of experiencing thromboembolic complications. One study found a higher incidence of PE in patients undergoing anterior approaches to the spine [5]. Although this may be true, we did not find this pattern in our study and further studies must be done in order to definitively identify an anterior approach as a risk factor for developing a PE in the post-operative setting. Theoretically, manipulation of the vessels and venous stasis caused by retraction may increase the propensity for clot development.

Historically, the standard for DVT prophylaxis in spine surgery patients has entailed mechanical measures with compression stockings, often with favorable results in prevention [1, 2, 6–8]. In high-risk patients undergoing spine procedures, IVC filter placement has been encouraged as a prophylactic measure [13, 18]. Chemical prophylaxis has taken a secondary role because of the high risk of hemorrhagic complications anecdotally described in the literature [3]. Yet, research examining the risk of developing postoperative hematomas from DVT prophylaxis with low-

dose heparin (LDH) has yet to find a definitive causal relationship between LDH and hematoma formation [19]. In theory, the risk of chemical prophylaxis can be disastrous. For example, patients undergoing lumbar decompression and instrumentation will undoubtedly have exposed bleeding surfaces associated with the surgery because of routine decortication that takes place intra-operatively [4]. Bleeding surfaces in addition to the lack of protective structures such as the lamina after a laminectomy can lead to cord compression if a hematoma were to develop. Such a complication could result in disastrous neurologic complications that potentially are irreversible. Nonetheless, the development of a fatal PE due to an absence of appropriate DVT prophylaxis is a disastrous complication as well [15]. Therefore, identifying high risk patients in theory can help to minimize the neurologic complications associated with aggressive chemical prophylaxis while also minimizing the risk of thromboembolic complications.

Patients who have significant risk factors, such as a previous history of PE/DVT or an underlying coagulopathy, should be evaluated preoperatively for the use of a temporary removable filter and also monitored very closely for the occurrence of postoperative thromboembolic complications. In addition, the risks and benefits of treating subclinical small isolated clots should be further investigated. Further research needs to be done in order to develop the most sensitive algorithm for appropriately ordering a spiral CT to rule out PE based on the clinical presentation in the postoperative setting. In addition, future studies should aim to integrate patient risk factors in order to develop a more sensitive and specific method for diagnosing PE in conjunction with imaging modalities. Developing an effective and efficient method for diagnosing and treating thromboembolic complications early can minimize significant morbidity and mortality in the population of patients undergoing spine surgery.

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