ORIGINAL ARTICLE

CT pulmonary angiography and pulmonary embolism following 5809 primary joint arthroplasties

Charlotte Allen, Richard Seinge, Rod Maxwell, Dilraj Thind

Abstract

Aim Controversy surrounds prevention, detection and clinical relevance of pulmonary embolism (PE) following arthroplasty in orthopaedic patients. We aimed to review the rates of computer tomography pulmonary angiography (CTPA), PE and fatal PE following total joint replacement.

Method Mixed retrospective/prospective review of CTPA requests and PE incidence amongst patients undergoing primary knee and hip arthroplasty.

Results The overall PE rate was 112/5809 (1.93%): 38/3473 (1.1%) and 74/2336 (3.5%) following total hip arthroplasty (THA) and total knee arthroplasty (TKA), respectively. Two deaths from PE occurred, both after TKA, a procedural mortality rate of 0.086%; the overall mortality rate was 0.034%. The rate of CTPA requests increased for the initial 7 years as did the rate of PE, in the last 2 years both rates fell.

Conclusion The findings are discussed in context of published data and with reference to studies suggesting the high sensitivity of CTPA may over diagnose clinically significant PE following arthroplasty if ordered without a robust method of determining the pre-test probability.

Prevention, detection and clinical relevance of venous thromboembolic events (VTEs) following arthroplasty are controversial. The detection rate varies widely from clinical trials to observational series.1–3 Scoring systems to quantify pre-test probability are not sufficiently discriminatory in the postoperative period. This, in combination with the high sensitivity of the gold standard PE detection method, CT pulmonary angiography (CTPA), may result in over diagnosis of pulmonary embolism.4–7

Overdiagnosis of clinically relevant PE in the perioperative period exposes patients to the risk of morbidity and mortality from anticoagulation treatment.2,8–10 but inadequately treated VTEs can also result in short and long-term morbidity and mortality. Preventative management for VTE is widely debated not only because of concerns with efficacy of various prophylactic strategies but also their risk to benefit ratio.1–3,10–12 The cost of various anticoagulation regimes is also considerable.4–7,13 The controversy is regularly reported in the press, and a range of international organisations have created guidelines recommending widespread prescription of anticoagulants.5,8–10,14–17

In 2006, at a public elective orthopaedic unit 7 km from the main city hospital, a 6-month retrospective audit of PE incidence following primary elective hip and knee arthroplasty was initiated. This occurred after three pulmonary emboli were diagnosed within a 10-day period. The audit was subsequently extended retrospectively to 2004 and data collection commenced prospectively to the present.

The aim of this paper is to describe the request rate of CTPAs, the rates of PE and PE-related mortality following primary hip and knee arthroplasty at an elective public orthopaedic unit from 2004 to 2013, and to compare this to published series.

Method

Patient selection—All patients in New Zealand are identified with a unique National Health Index (NHI) number which can be used to search national and local databases. Patients coded as having a primary elective
hip or knee arthroplasty were included, retrospectively from 2004–2006 and prospectively from 2006–2013 (years run from 1 July to 30 June).

To identify patients who had a PE the medical records of all patients coded as having a CTPA within ninety days of surgery were reviewed to determine the indication of the CTPA and findings i.e. PE or no PE. In addition the medical record of patients with a code of PE in their discharge summary were examined to discover patients who may have been diagnosed as having a PE without a CTPA—e.g. with a ventilation perfusion scan. If death occurred within 90 days of surgery the medical record was examined to determine if death was related to a PE.

The recorded causes of death (from the death certificate) of any of the study population who had died up to April 2013 were provided by the Ministry of Health (with Local Ethics Committee approval). These records were examined to determine if any death was recorded as being from PE.

Data collected included date and type of procedure, sex, age, American Association of Anesthesiologists score (ASA), anaesthesia type, symptoms resulting in CTPA request, date of CTPA, result of CTPA and date of death.

**Patient management**—The patient’s surgical and anaesthetic management was not controlled however all surgeons employ a tourniquet for knee arthroplasty. Some aspects of care were guided by local guidelines—e.g. prophylactic antibiotic use and VTE prophylaxis. The VTE guideline has changed, as described below, over the period of the data collection.

Early mobilisation (day one) occurs unless medically contra-indicated. Approximately two-thirds of patients receive spinal anaesthesia (Table 1), thromboembolism-deterrent stockings are not employed. In 2004 chemical VTE prophylaxis consisted of aspirin 150 mg once daily commencing on the first postoperative night for 6 weeks postoperatively unless contraindicated. In 2007 postoperative mechanical prophylaxis, foot pumps, were employed for arthroplasty patients until full mobilisation or a minimum of 72 hours postoperatively. In March 2010, due to a formulation change, the aspirin dose was changed to 100 mg; simultaneously the initial dose advanced to the night before surgery, the 6-week postoperative course remained unchanged.

Prophylactic dose Enoxaparin from the first postoperative night (in hospital only) is reserved for patients identified as higher risk of VTE (bilateral surgery, previous VTE, body mass index >30 and predicted poor postoperative mobilisation, bed rest or poor mobility preoperatively, impaired cardiac function [e.g. ejection fraction <40%], known malignancy). Aspirin is then commenced from discharge for 6 weeks. An individualised regime is occasionally prescribed when the surgeon and anaesthetist deem this appropriate.

CTPA scans are in the main public hospital, 7 km from the elective orthopaedic unit. The CTPA protocols were performed on a GE VCT 64-slice CT until July 2012 when the Siemens Somatom Definition Flash 128-slice dual-tube scanner was installed. CTPAs are reported by consultant radiologists.

**Statistical analysis**—Data were into entered into Excel (Microsoft, Redmond, WA, USA). This was also used for the main analysis. Stata, version 12 (StataCorp, College Station, TX, USA) was also used for part of the analysis. Data were described using proportions and percentages where appropriate. Possible linear association between quantitative variables was assessed using scatterplots and Pearson’s correlation coefficient. Subsequent linear regression was used to quantify this relationship, if applicable.

**Results**

There were 5809 eligible patients in the study period, 2336 (40.2%) knee and 3473 (59.8%) hip arthroplasties (Table 1).
Table 1. Demographic data

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<th>ASA 1</th>
<th>ASA 2</th>
<th>ASA 3</th>
<th>ASA 4</th>
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<tbody>
<tr>
<td>Male</td>
<td>41.7%</td>
<td>9.6%</td>
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<tr>
<td>Female</td>
<td>58.3%</td>
<td>55.4%</td>
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<td>GA†</td>
<td>32.5%</td>
<td>34.4%</td>
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<td>SAB†</td>
<td>64.8%</td>
<td>0.6%</td>
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<tr>
<td>Epidural†</td>
<td>0.06%</td>
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<tr>
<td>Regional limb block†</td>
<td>2.67%</td>
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†Anaesthesia type – percentages based on available data (89.8% patients, some patients had more than one modality).

291 patients had a CTPA (5.2%) of which 106 (36.4%) were positive, two other patients had indeterminate CTPA report and were anticoagulated. In addition two patients (one in 2010–11 and one in 2012–13) had a PE detected by a V/Q scan. Two deaths attributed to PE occurred in the study period. Both occurred after total knee arthroplasty (TKA), one 3 days the other 65 days postoperatively, neither patient had a CTPA.

The medical record review revealed one other death associated with PE 4 days after a hip arthroplasty but PE was not recorded on the death certificate. In this case the CTPA demonstrated a single subsegmental embolism with some right heart strain, reported as unlikely to be secondary to the embolus. This patient had known chronic obstructive lung disease which was the recorded cause of death.

The overall PE rate in the study population, including those diagnosed by V/Q scan and those treated for PE with a negative CTPA, was 112/5809 (1.93%). The overall PE mortality rate was 0.034%, 0.086% following TKR and 0% following THR.

The CTPA request rate by year varied over the period between 3.3% and 6.6% (Figure 1) and the positive CTPA rate varied from 19% to 60% (Figure 2).

Figure 1. CTPA request rate after hip and knee arthroplasty
There appears to be a linear correlation for the association between CTPA requests and positive PE detection (r=0.74) (Figure 3). The regression coefficient between CTPA request and PE detection is 0.78 (95% CI, 0.22–1.35) with evidence against the null hypothesis of no linear association between the two (P=0.013, t-test). From the data collected every 1% increase in CTPA requests results in a 0.78% increase in reported PE.

The overall PE rate varied between 0.9% (2004–05) and 4.0% (2010–11) with the rate following TKR consistently higher than that following THR (Figure 4).
The majority, 64%, of CTPAs were performed on days 1 (10.4%), 2 (19.6%), 3 (22.6%) and 3 (11.3%) postoperatively, this pattern was consistent between THR and TKR. The mean rate of positive and negative CTPAs was 37% and 63% respectively; however the negative rate declined from 83% (day 1) to 64% (day 2) before levelling off to 58% and 50% (days 3 and 4 respectively) (Figure 5).
Of the 106 positive CTPAs 84 (79%) had filling defects proximal to, or at the segmental level and of these 84 patients 33 (39%) were reported as having right heart strain—i.e. 33 of the total 106 (31%). 22 patients (21%) had subsegmental defects.

Discussion

DVT and PE are known complications of arthroplasty occurring in up to 10% of cases\textsuperscript{11,14} and can result in significant morbidity however mortality is usually low.\textsuperscript{1,3,18} We have recorded a relatively high PE rate however, fitting with other studies, the mortality rate from PE is reassuringly low.

In New Zealand, the Perioperative Mortality Review Committee reported the 30-day mortality rate from PE following elective admissions (all specialties) associated with general or regional procedures between 2006 and 2010; the overall rate was 0.008%. Over the same period the comparable rate after acute admission (all specialties) was six times higher, 0.05%.\textsuperscript{19}

Hip and knee arthroplasties (including revisions) were reported to be the most common elective procedures resulting in death from PE, with respective mortality rates of 0.01% and 0.06%. Whilst elective lower limb arthroplasty is quoted as a high risk procedure for VTE the mortality rate from PE is very low and has decreased over the last 4 decades.\textsuperscript{20,21}

Many studies have reported on different methods of VTE prophylaxis post elective surgery. No one method has been shown to be consistently superior at preventing mortality from PE.\textsuperscript{11,12,19–21} Patients in the described population routinely receive chemo thromboembolism prophylaxis with aspirin, which has a favourable risk benefit profile.\textsuperscript{3,12,15,22} in addition to mechanical prophylaxis with foot pumps from 2007.

It has been calculated, from a similar series of 4253 primary arthroplasties (fatal PE frequency 0.07%) that to demonstrate efficacy of different chemo prophylactic VTE regimes 67,000 patients per study arm would be required.\textsuperscript{3} This series of patients were also managed using predominately spinal anaesthesia, early mobilisation and aspirin as VTE chemo prophylaxis. Surrogate outcomes, such as DVT rates, are often employed to demonstrate VTE prophylaxis efficacy as these occur in higher numbers.

The low disease prevalence and the high sensitivity of modern CTPA increases the risk of detection of non-clinically relevant PEs if CTPAs are requested without a robust pre-test probability determination. Currently in the surgical population there is no method of separating clinically relevant and non-relevant PEs, all patients are anticoagulated exposing them to potential harmful side effects.\textsuperscript{23,24}

Diagnosis of PE generally relies on one of a number of scoring systems designed to triage patients’ likelihood of having a pulmonary embolism (PE) or deep vein thrombosis (DVT) by providing a pre-test probability to determine the need for investigation.\textsuperscript{25,26} However, although these scoring systems are applicable in the community setting, they are insensitive when applied to most postoperative orthopaedic patients.\textsuperscript{27}

The majority of postoperative arthroplasty patients would score 4.5–6 using the Wells scoring system (clinical suspicion – 3, immobilisation or surgery previous 4 weeks – 1.5, and heart rate >100/min – 1.5 points, respectively).\textsuperscript{25} This score associated with a positive d-dimer (present in post arthroplasty patients) would predict a high likelihood of PE indicating the need for further investigation, commonly CTPA. A study investigating the efficacy of scoring systems in orthopaedic trauma patients\textsuperscript{27} has been undertaken but to our knowledge there have been no studies in patients undergoing arthroplasty.
With no reliable scoring system the clinician must rely on non-specific symptoms, signs and investigations to decide which patients warrant a CTPA. Wiener et al’s paper reviews the use of CTPA in over diagnosis of pulmonary embolism and discusses ways in which the issue could be addressed; however, unfortunately the lack of suitable pre-test probability scoring systems for surgical patients is not mentioned.\(^5\) Wiener also argues that although more PEs are being detected with CTPA the mortality rate from PE is falling suggesting that now smaller more distal PEs are being detected but these are of dubious significance.

More recent studies demonstrate the potential problem of inadequate pre-test probability in this patient population. In the first,\(^4\) 48 asymptomatic patients undergoing primary hip and knee arthroplasty with enoxaparin cover, underwent a CTPA 24–36 hours postoperatively. Five percent of the hip and 41% of the knee arthroplasty patients had a positive CTPA. All 12 patients with a positive study CTPA were discharged from hospital uneventfully with no anticoagulation treatment. In the second study by Cha et al, a CTPA were performed on 363 patients undergoing major orthopaedic surgery receiving no chemo thromboprophylaxis, between 5–14 days postoperatively.\(^28\) 12.3% of knee arthroplasty and 4.3% of hip arthroplasty patients were diagnosed as having PE. The overall PE rate for the study population was 6.6% with only 1.1% patients symptomatic.

Both these studies and ours demonstrate the potential problem of performing CTPA without defining the pre-test probability particularly as studies suggest that small sub segmental clots may not need anticoagulation treatment\(^10\) even in the orthopaedic population.\(^4,5\) A study by Berman et al reveals how asymptomatic PE may occur. Transoesophageal echocardiography demonstrated showers of echogenic material in all patients after tourniquet deflation during knee arthroplasty; 5% patients subsequently developed clinically relevant PE.\(^29\)

There are significant patient and health provider costs associated with over diagnosis and over treatment of PE. Patient costs include anxiety and inconvenience, risks from radiation and contrast exposure and subsequent anticoagulant morbidity. Health providers must fund the CTPA, additional hospital stay and the costs associated with anticoagulation and monitoring.

Anticoagulation in the early postoperative period carries significant risks of haemorrhage with associated morbidity,\(^2,7\) anticoagulants are a leading cause of drug related mortality,\(^9,11,25\) (approximate 5 % risk of a major bleed and fatal bleed 0.1%).\(^8,10\) Increasing concern has resulted in studies investigating the adverse events associated with chemo thromboembolism prophylaxis.\(^11,12,30\) A limitation of this study was that we were unable to quantify the morbidity from anticoagulation in this patient population but are aware of several anecdotal reports with in this population of morbidity secondary to anticoagulation.

Taking into account these facts, it is not surprising that there is considerable scepticism among Australasian Orthopaedic Surgeons about the efficacy and appropriateness of VTE prophylaxis guidelines.\(^31\)

We note an initial rise in CTPA requests and secondary increase in reported PE rate and hypothesise it could be due to increased awareness from an initial run of three PEs in ten days and then the commencement of the audit. Awareness of the potential problem of ordering CTPAs in this population without adequate pre-test probability has increased in the last 2 years and we speculate this may have accounted for the fall in CTPA request rate and consequent reported PE incidence observed in 2011–12 and 2012–13.

This study has some limitations. Some of the data was obtained retrospectively. Clinical management was not controlled although relatively consistent due to hospital protocol. If patients have a PE after discharge and attend a hospital out of the catchment area of the public hospital would be missed, however deaths would be captured. Reporting of CT scans varied over the study period with no
standard method for reporting size or distribution of filling defects making it difficult to assess the likely clinical relevance in this retrospective study.

This study adds to the controversies described and echoes the findings of other studies that question the clinical relevance of all CTPA diagnosed PEs in the postoperative period and how PE can be more reliably assessed in this population.4–6

We believe that work is required to compile a suitable pre-test probability scoring system for CTPA investigation of possible PE in the post-arthroplasty population in order to help determine clinically relevant PE. In addition the risk to benefit ratio of anticoagulation treatment verses no intervention for minor or subsegmental PE detected by CTPA in this population requires studying.

Competing interests: Nil.

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References

5. Wiener RS, Schwartz LM, Woloshin S. When a test is too good: how CT pulmonary angiograms find pulmonary emboli that do not need to be found. BMJ. 2013 Jul 2;347(jul02 2):13368–8.


17. NICE. Venous thromboembolism: reducing the risk. 2010;Feb 12:1–50.


