

# **Out of Hours Multidetector Computed Tomography Pulmonary Angiography: Are Specialist Registrar Reports Reliable?**

**George C. Jakanani, FRCR; Rajesh Botchu, FRCR; Sumit Gupta, MRCP;  
James Entwisle, FRCR; Amrita Bajaj, FRCR**

## **ABSTRACT**

**Aim** The purpose of this study was to assess the accuracy of the trainee radiologist's report for CTPA, and determine agreement or discrepancy with the final verified consultant report.

**Materials and Methods:** We prospectively analysed 100 consecutive out of hours CTPA examinations. Fifty one male and 49 female subjects were included in the study. Mean (range) age of patients scanned was 63.7 (17 – 98) years.

**Results:** 18 of the 100 subjects (18%) had findings positive for PE. The interobserver agreement for PE between on-call radiology registrars and consultant radiologists was almost perfect [Kappa = 0.932 (p<0.0001; 95% CI, 0.84 – 1.0)]. There was one false negative CTPA report. Eighty two CTPA scans (82%) were reported as negative for PE by consultant radiologists. In this group, there was a single false positive interpretation by the on call specialist registrar. The interobserver agreement for all findings between registrar and consultant reports was almost perfect [weighted Kappa = 0.87 (p<0.0001; 95% CI, 0.79 – 0.96)]. The overall discrepancy rate, including both false positive and false negative findings, between the on-call radiology registrar and consultant radiologist was 8% (8 of 100).

**Conclusion:** CTPA reports by radiology registrars can be relied and acted upon without any major discrepancies. There is a relatively much higher proportion of

patients with alternative diagnoses mainly infective consolidation and heart failure presenting with similar symptoms and signs of pulmonary emboli. It is imperative for the trainee to be systematic and review all images if observational omissions are to be reduced.

# **Out of Hours Multidetector Computed Tomography Pulmonary Angiography: Are Specialist Registrar Reports Reliable?**

## **INTRODUCTION**

Multidetector computed tomography pulmonary angiography (CTPA) is now the most common imaging modality in the evaluation of suspected pulmonary embolism (PE). A large number of CTPAs are performed out of hours, and within teaching hospitals, the initial provisional reports are issued by the trainee radiologist and not checked until the following morning by the consultant radiologist. These trainee radiologist are referred to as Specialist registrar or SpR who undergo structured specialist training in their choose field of medicine. This is at least over a 5 year period in Radiology at the end of which the registrar is considered trained, ready to be a consultant. (Appendix 1) The SpR's do on site training out of normal working hours on a rotational basis which is referred to as "on call rota" These provisional reports are crucial as they provide the basis for out of hours clinical decisions. The purpose of this study was to assess the accuracy of the trainee radiologist's report for CTPA, and determine agreement or discrepancy with the final verified consultant report. To the best of the authors' knowledge, this is the first study of its kind performed in a UK teaching hospital.

## **METHOD AND MATERIALS**

We prospectively analysed 100 consecutive out of hours CTPA examinations. These were performed during a 28 day period from August to September 2008. 64 scans were performed on a 16 slice MDCT sytem (Siemens Somatom Sensation, Siemens AG, Munich, Germany; Technical parameters – 120 Kv, effective mAs 140, rotation

time 0.5, 0.75 collimation with a reconstruction slice thickness of 1mm, reconstruction interval of 0.5 mm.). 36 scans were performed on a 64 slice MDCT system (Aquilion, Toshiba, Tokyo, Japan; Technical parameters- 120 Kv, effective mAs 182, rotation time 0.5, pitch of 0.828 and reconstruction slice thickness of 1 mm, reconstruction interval of 0.5 mm).

Images were acquired after injection of 100ml of iohexol 350 (350 mg iodine/ml, GE Healthcare, Oslo, Norway) using bolus trigger set at 100 HU on the pulmonary trunk. Images were reviewed on a patient archive and communication system (PACS) workstation (AGFA Impax 5.1, Morstel, Belgium). Analysis of CT images was performed on axial, coronal and sagittal reformatted images (1mm multiplanar reconstructions). Both soft-tissue and lung windows were used to identify subsegmental bronchi and arteries.

Acute PE was diagnosed when there was filling defect within the vessel or when vessel truncation implied the presence of occlusion. The level of PE was categorized as central, lobar, segmental and subsegmental.

The initial provisional reports issued by the on call specialist registrar were prospectively collected and findings documented. All trainees on the on call rota had completed at least 2 years of specialist radiology training and had been signed off to at least level 3 to report CTPA according to the Royal College of Radiology trainee portfolio (Appendix 2).

The provisional reports were verified by a consultant radiologist within 24 hours of the examination and the consultant report was used as the reference standard. Both the trainee registrar and consultant groups were unaware of the study in progress at the time of their reports in order to avoid bias.

Two cardiothoracic radiologists (JJE and AB), who were blinded to both the initial registrar and final verified consultant reports reviewed the cases with discrepancy and issued a final report by consensus.

Statistical analysis was performed using SPSS for Windows, Rel. 16.0.1.2008. Chicago: SPSS Inc and an online statistical computation website (<http://faculty.vassar.edu/lowry/kappa.html>). Indices of agreement were calculated as described previously [1]. Kappa (unweighted and weighted) statistic was used for an inter-observer reliability analysis. Kappa statistic were interpreted as indicating poor( $\kappa < 0.2$ ), fair( $0.21 < \kappa < 0.4$ ), moderate( $0.41 < \kappa < 0.6$ ), substantial( $0.61 < \kappa < 0.8$ ) and almost perfect( $0.81 < \kappa < 1.0$ ) observer agreement.[1,2] A p value of  $< 0.05$  was taken as statistically significant.

## **RESULTS**

One hundred consecutive out of hours CTPA examinations performed at a university teaching hospital over 16 day period were prospectively included in this study. These were reported by 16 different SpR and the final reports were verified by 6 Consultants, three of whom were subspecialist Consultants in Cardiothoracic Radiology. Fifty one male and 49 female subjects had CTPA examinations. Mean (range) age of patients scanned was 63.7 (17 – 98) years.

18 of the 100 subjects (18%) had findings positive for PE. The interobserver agreement for PE between on-call radiology registrars and consultant radiologists was almost perfect [Kappa = 0.932 (p<0.0001; 95% CI, 0.84 – 1.0)]. There was one false negative CTPA report in the specialist registrar group. This was for a PE in a single segmental pulmonary artery branch. 6 of the 18 subjects with PE had other concurrent chest findings. These were all correctly reported by the registrar. A summary of positive and negative interpretation of CTPA scans for PE by on-call radiology registrars and consultant radiologists is presented in Table 1. Table 2 is a summary of any additional chest findings in the 18 subjects with PE.

Eighty two CTPA scans (82%) were reported as negative for PE by consultant radiologists. In this group, there was a single false positive interpretation by the on call specialist registrar. The consultant opinion in the false positive case was that the finding was artefactual, and caused by suboptimal pulmonary opacification in a technically inadequate examination. The expert panel agreed with this assessment. 44 of the 82 subjects with no PE had significant other chest findings on CTPA sufficient to explain the clinical symptoms. Six of the 44 were unreported by the registrar. The six cases included two subjects with CT evidence of heart failure, a subject with CT features of hypertrophic obstructive cardiomyopathy (HOCM) (Figure 1), a missed small pneumothorax, a subject with bronchiectasis, and another with subtle early interstitial lung disease. One subject had an incidental inter-atrial septum aneurysm which was not felt to have been the cause of symptoms (Figure 2). The remaining 37 of the 82 subjects with no PE had no other additional chest findings and had completely normal CTPA examinations. Table 3 is a summary of the

additional chest findings in patients with no PE highlighting the findings missed by SpR.

The interobserver agreement for all findings between registrar and consultant reports was almost perfect [weighted Kappa = 0.87 ( $p < 0.0001$ ; 95% CI, 0.79 – 0.96)]. The overall discrepancy rate, including both false positive and false negative findings, between the on-call radiology registrar and consultant radiologist was 8% (8 of 100) (Table 4).

The important missed finding of HOCM was asymptomatic prior to scan and is now under the care of a cardiologist. The other missed findings of bronchiectasis and early ILD were unlikely to explain the symptomatology but were in any case referred to chest consultant. The patients with heart failure were managed accordingly by the Medical team. Patient with small pneumothorax did not need any intervention.

## **Discussion**

CTPA is a quick and reliable way of diagnosing pulmonary embolism. A prompt diagnosis is essential to decrease the morbidity and mortality arising from this condition [3]. In UK teaching hospitals, the on call radiology registrar discusses, authorises and supervises all out of hours CT examinations, and thereafter issues a provisional report to the referring clinical team. This provisional report is the basis upon which clinical management decisions are made, making it vitally important that it is accurate and reliable.

The accuracy of out of hours radiology resident reports has previously been reported in a number of studies in the American literature with respect to CTPA, CT of the head, trauma imaging and in suspected appendicitis [4,5,6,7,8,9]. Radiology departments within the NHS have different clinical audit and clinical governance mechanisms to ensure that out of hours patient safety is not compromised. The current study was developed after an initial small audit of out of hours specialist registrar activity, and to the best of the authors' knowledge, is the first to report on the accuracy of out of hours specialist registrar CTPA reports within a UK teaching institution.

The study demonstrates excellent agreement between specialist registrar and consultant reports in the diagnosis or exclusion of PE. This is in keeping with a number of studies which have shown that appropriately trained radiology residents can provide a safe CTPA service out of hours [10, 11, 12]. Shaham et al have reported good interobserver agreement between on call resident and specialist staff in reporting CTPA [10]. In a similar study, Safriel et al have reported that the provisional report can be relied upon without any significant discrepancy [11].

In common to our study, another report shows evidence that exposure to 2 years of radiology training enables a resident to provide a useful and reliable provisional report for CTPA [12]. In this respect, our results validate the accuracy of the training assessments done by our local educational supervisors and consultant trainers with regards to signing off trainees appropriately for on call reporting. The high accuracy of these trainee reports also shows that individual trainees could potentially be signed off as completely independent (Level 4 competence) earlier on, possibly in the fourth



year of training, freeing up valuable consultant time and allowing for more efficient use of consultant resources.

The single case of false positive interpretation due to inadequate pulmonary tree opacification highlights the need for adoption of robust scanning protocols, and reinforces the need for meticulous attention to detail with regards to exam technique [13, 14]. It is important that both trainees and radiographers are aware of how various technical parameters can affect the accuracy of what is otherwise an excellent diagnostic tool. With the new generation of multi-detector scanners, our own experience shows that technically inadequate examinations lead to suboptimal opacification in the subsegmental branches of the pulmonary vasculature. At the same time, a properly performed MDCT allows increased detection of PEs in the subsegmental arteries, as opposed to earlier single slice scanners and conventional pulmonary angiography [15]. Whether a missed sub segmental PE in this location is clinically significant however continues to be a matter of considerable debate with a recent study showing that despite multidetector CTPA increasing the detection rate of subsegmental PEs, follow up at 3 months in these patients suggests that untreated PEs in this location may not affect clinical outcome [16].

We showed a high proportion of patients without PE but with significant other findings sufficient to explain the patient's presenting symptoms. This is not surprising given the non specific clinical presentation of PE. This ability to provide an alternative diagnosis is one of the main reasons why CTPA has replaced conventional pulmonary angiography as the gold standard test in imaging suspected pulmonary embolism. The commonest findings in our group of patients were pneumonia,

atelectasis and heart failure (Table 2). This is in keeping with previous studies in the literature. Richman et al in a multicentre study involving 1025 patients showed that pneumonia was the most common non thrombotic finding in patients with no PE [17]. In another study, Tsai et al reported atelectasis and pneumonia as being the most common findings [18]. Within the context of the current study, what our results and these aforementioned studies demonstrate is the importance of CTPA in providing an alternative explanation for a patient's acute symptoms. In an out hours setting, the radiology registrar therefore becomes the first person to point out the presence of for example pneumonia or heart failure, allowing the clinical team on the wards, who nowadays are often quite junior and inexperienced, to treat these conditions expeditiously. The excellent agreement in our study on these findings is testament to the fact that this is a message that is continuously emphasized to our radiology registrars during their training.

It is important to point out that there are some additional findings that will be entirely incidental but will require follow up, for example the subjects with inter atrial septum aneurysm and HOCM from our series. The need to have appropriate mechanisms for follow up is also highlighted in a recent review of 589 examinations by Hall et al which showed that CTPAs were more than twice as likely to reveal an incidental pulmonary nodule or adenopathy than PE [19].

What is clear on review of the 6 subjects with significant unreported findings is that in 5 of these subjects, the findings were not reported due to what we believe is the inherent satisfaction of search that plagues the early years of radiology training.

[20]The subject with HOCM highlights how the heart is often a blind spot for most

non cardiothoracic radiologists. The case is a good example of how the exquisite detail provided on MDCT images has made it mandatory for every radiologist to be conversant not only with the normal cross sectional imaging anatomy of the whole body , but in this case the CT manifestations of cardiac conditions which have traditionally been imaged by other modalities in the past.

We do accept that this study had a few limitations. Firstly the study had a relatively small cohort of patients. Also the Consultants who verified the reports were not blinded to the SpR's report raising the possibility of reporting bias. Our institute does have high throughput of CTPA's and all the consultants in the study have sufficient exposure to cardiothoracic cases on a regular basis.

CTPA reports by radiology registrars can be relied and acted upon without any major discrepancies. There is a relatively much higher proportion of patients with alternative diagnoses mainly infective consolidation and heart failure presenting with similar symptoms and signs of pulmonary emboli. It is imperative for the trainee to be systematic and review all images if observational omissions are to be reduced.

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## **Appendix 1**

The Royal college of Radiologists. Clinical Radiology/ Training and qualifications /  
Specialty Training / Becoming a Clinical Radiologist

## **Appendix 2: Royal College of Radiologists Trainee Portfolio Competencies**

**Level 1** – The radiology trainee has a comprehensive understanding of the principles of the procedure including, where applicable, complications and interpretation of results and has witnessed the procedure being performed.

**Level 2** – The radiology trainee is able to carry out the procedure under direct supervision of a Consultant

**Level 3** – The radiology trainee is able to carry out the procedure under indirect supervision i.e. Consultant is available for advice but is not physically present during the investigation

**Level 4** – The radiology trainee is able to carry out the procedure competently and independently (independent competence)

## **Figures and Legends**

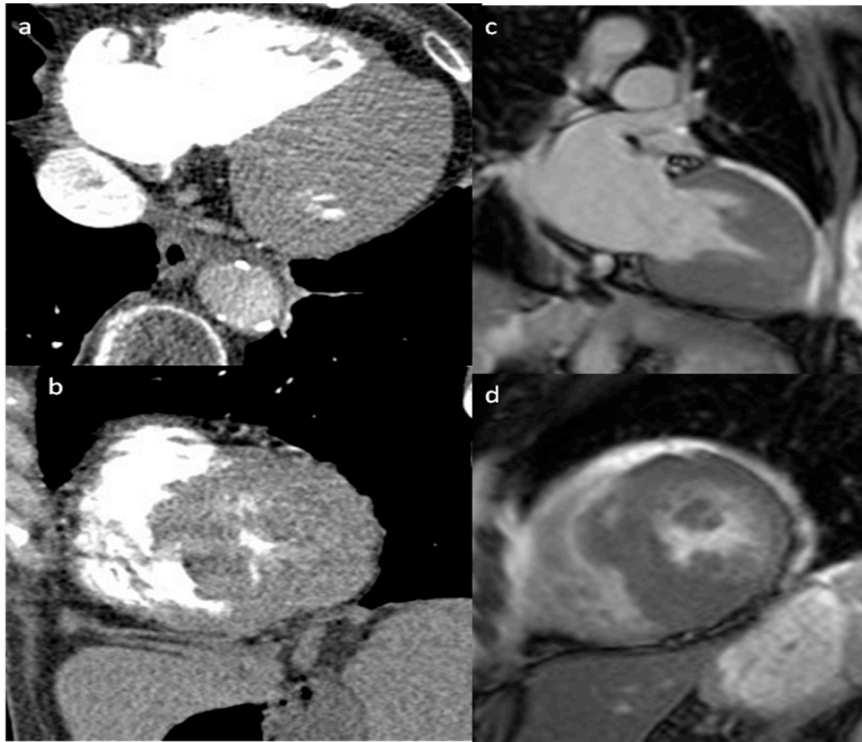


Figure 1a and 1b: 84 female admitted following collapse with mild SOB and raised D dimmers. Selected axial and short axis CT reconstructions show grossly hypertrophied left ventricle in the mid and distal walls & apex with mid cavity obliteration suggestive of HOCM. Figure 1c and 1d: Long and short axis MRI images show small left ventricular cavity and severe hypertrophy in the inferoseptal region and apical zones. The hypertrophied regions demonstrated poor contractility and overall LV function was mildly impaired.



Figure 2



77 year old male who underwent coronary bypass graft and seen at follow up clinic visit acutely dyspnoeic. No PE demonstrated on CTPA. Axial image from CTPA shows focal outpouching of the interatrial septum to the left into the left atrium containing contrast, likely an interatrial septal aneurysm. This was confirmed on transoesophageal echocardiography which also revealed a tiny small associated patent foramen ovale with right to left flow confirmed on bubble contrast.

## Tables

**Table1- Correlation between consultant and registrar reports**

	<b>Consultant Report</b>		
<b>Radiology Registrar report</b>	Positive	Negative	Total
<b>Positive</b>	17	1	18
<b>Negative</b>	1	81	82
<b>Total</b>	18	82	100
<p><b>(1) Overall proportion of agreement (OA) = 0.98</b></p> <p><b>(2) Proportion of positive agreement (PA) = 0.94</b></p> <p><b>(3) Proportion of negative agreement (NA) = 0.99</b></p>			

**Table 2: Summary of additional chest findings in patients with PE (N= 18)**

None	12
Lung findings	
Infarcts	1
Consolidation	2
Cardiac	
Right heart strain	1
Right heart strain and bronchiectasis	1
Right heart strain, atelectasis and pleural effusion	1

**Table 3: Summary of findings in patients with no PE (N= 82 patients)**

No PE and no lung findings	37
Lung findings	
Pneumonia	5
Pneumonia and pneumothorax	1
Pneumonia and atelectasis	2
Atelectasis	1
Atelectasis and effusion	4
Pneumothorax	1 Missed by SpR
Emphysema	6 (2 Missed by SpR)
Bronchiectasis	4 (1 Missed by SpR)
Lung mass	1
Pleural effusion	3
Pleural effusion, emphysema and fibrosis	1
Lung metastases	1
Bone (spine and rib) metastases	1
Cardiac	
Failure	7(2 Missed by SpR)
Pericardial effusion	2
HOCM	1(Missed by SpR)
Inter atrial septum aneurysm	1
Lung and cardiac findings	
Pneumonia and failure	2

Interstitial lung disease and failure	1(Missed by SpR)
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**Table 4: Overall agreement and discrepancy**

	<b>Consultant Report</b>			
<b>Radiology Registrar report</b>	<b>PE present</b>	<b>Other significant findings but no PE</b>	<b>Normal scan</b>	<b>Total</b>
<b>PE present</b>	17	0	1	18
<b>Other significant findings but no PE</b>	0	39	0	39
<b>Normal scan</b>	1	6	36	43
<b>Total</b>	18	45	37	100