

Learning Curve for Transradial and Transfemoral Coronary Angiography amongst Cardiology Trainees

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Abstract

A decrement in fluoroscopy time (FT) is one objective measure of competency in coronary angiography.

Aims: To establish if a difference in FT exists between consultants and trainees, investigate if trainees have shorter FT with increasing seniority, compare transradial (TR) and transfemoral (TF) FTs of trainees, and determine a minimum number of TR cases to overcome the potential “learning curve”.

Methods and results: The total, TF and TR FTs in patients was assessed over four years. Cases were dichotomized to with trainee (trainee) or without trainee (consultant) present in the catheterization laboratory. Complex cases were excluded. 1699 patients underwent diagnostic coronary angiography during the study period, where the trainee was present in 707 cases. Patients in the trainee cohort were older, but there was no other significant difference in demographics. The presence of a trainee resulted in longer FTs (6.0 versus 3.9 min, $p < 0.001$). The median FT of trainees improved between their first and second fifty cases (6.5 mins vs 5.2 mins, $p\text{-value} < 0.0001$). After the first 50 TR cases, median trainee TR FT fell within the IQR of consultants.

Conclusion: Cardiology trainees have longer total, TF and TR fluoroscopy times compared to consultant cardiologists. However, these times improved with increasing experience.

Keywords: Fluoroscopy time; Trainee competency; Transradial; Transfemoral

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Introduction

The transradial (TR) approach is increasingly being used as the default access for coronary angiography. National cardiac governing bodies, such as the Cardiac Society of Australia and New Zealand, assess competency by requiring trainees to perform minimum angiography case numbers throughout their training [1]. There are no guidelines, however, to the minimum number of TR cases a trainee should complete, neither are there standardized tools for the assessment of proficiency in coronary angiography by the end of three years of cardiology training.

Fluoroscopy time (FT) has been suggested as an objective measure of proficiency where a decrement in FT time indicates increasing competency [2]. As expected, trainees have been shown to have, in general, longer FT as compared with their supervisors

[3,4]. However, it is unknown if cardiology trainees improve their efficiency in performing coronary angiography particularly in the first few years of training. In addition, although there is a learning curve of operators new to TR angiography, there is limited data on the difference in FT of trainees performing TR and TF angiography

The aims of this study are to:

- (i) Establish if a difference in FT exists between supervisors and trainees
- (ii) Investigate if trainees have shorter FT with increasing seniority
- (iii) Compare FT of cardiology trainees between TR and TF approaches

- (iv) Determine a minimum number of TR cases to overcome any potential “learning curve”.

Methods

The FT in patients undergoing coronary angiography (with left ventriculography) was assessed at the University Hospital Geelong, a single tertiary referral center, from February 2010 to January 2014. Assessment was restricted to cases performed in the outpatient/ambulatory or elective cardiac catheterization laboratory. TF or TR approaches were performed as per cardiologists' preference.

Study design and protocol

The dates of this study were chosen to capture the entire 24-month tenure of eight individual cardiology advanced trainees. Trainees were supervised by 7 cardiologists, of which two were general cardiologists highly experienced in TF coronary angiography and five interventional cardiologists deemed experienced in both TF and TR angiography as per the ESC consensus document [5]. TF and TR cases were dichotomized to with trainee (trainee) or without trainee (consultant) present in the catheterization laboratory.

Transradial cases were predominantly undertaken via the right radial artery and the use of antispasmodic agents such as Verapamil or Glyceryl trinitrate (GTN) were used as per cardiologist preference. A cardiologist was all present and/or supervised all cases performed. FT was collected in all cases and expressed in minutes. Each trainee performed a median of 49 (IQR: 21–97) TR and 55 (IQR 27–96) TF cases in each year of training thus arbitrarily fifty cases were chosen as a cut-off to assess for improvement in FT.

Complex cases (coronary artery bypass graft studies, ad hoc percutaneous coronary intervention, fractional flow reserve and right heart studies) were excluded. Trainee attendances at cases performed in the in-patient or acute catheterization laboratory were not included in this study, as a proportion of cases proceeded to coronary intervention. In addition, planned PCI cases were also not included.

Statistical analysis

Non-normally distributed continuous variables are reported as a median with the interquartile range (IQR) in square parenthesis and compared using non-parametric tests. Categorical variables are reported as n (%) and analysed using Chi-square, Fisher test, Kruskal-Wallis test or Wilcoxon rank sum test where appropriate. Variables with an alpha significance level of 0.05 were considered significant. Statistical analysis was performed using the R statistical package, version 3.2.5, Vienna, Austria.

Results

1,699 patients underwent outpatient coronary angiography during the study period. Of these, 425 complex cases were excluded leaving a study total of 1274 patient who had coronary angiography with left ventriculography. A trainee was present (trainee) in 707 (55.5%) and absent (consultant) in 567 (44.5%) cases.

Baseline characteristics of the patients undergoing outpatient coronary angiography are shown in **Table 1**. Although patients in the trainee cohort were older (70.0 vs 65.0 years, p-value=0.01), there was no statistically significant difference in gender, height, weight or body mass index (BMI). In addition, trainees did less radial and more femoral cases than consultants (47.4 vs 57.5% and 52.6 vs 42.5%, p-value<0.0004). TF had a 100% procedural success rate, whilst there was a TR to TF conversion rate of 5.5%. Over the 4 years of the study, there were an increasing number of TR cases performed (41.2 vs 47.2 vs 52.0 vs 68.4, p-value<0.001), with a corresponding decline in the number of TF cases.

Fluoroscopy times

The median overall fluoroscopy times across both groups during the study period was 5.0 minutes (IQR 3.4 – 7.4). The FT in both trainee and consultant cases improved over the duration of the study, with a median FT of 6.3 minutes in 2010 versus a FT of 4.7 in 2013. TR cases took longer to complete than TF cases (5.7 vs 4.6 minutes, p-value<0.001). Comparing consultant and trainee cases, the presence of a trainee during the case affected the FT. The total, TR and TF FT in trainee cases was longer than that in consultant cases (**Table 2**).

Among trainee cases, the median total FT improved with increasing seniority and between their first fifty versus the second fifty cases (6.5 mins vs 5.2 mins, p-value<0.0001). A similar improvement was seen when cases were separated into radial and femoral cases (7.1 mins to 6.1 mins, p-value 0.00015 for TR and 5.9 mins to 4.7 mins, p-value<0.0001 for TF) (**Table 3**). When compared to consultants, the median FT of trainees fell within the 75% quartile of their supervisors in their second year. The total, radial and femoral median FT of consultants, first year trainees and second year trainees are depicted in **Figures 1-3**.

Table 1 Baseline characteristics.

Variables	Consultant (n=567)	Trainee (n=707)	p-value
Age, years (median)	65.0 (57.5-72.3)	70.0 (61.0-77.3)	0.01
Males, %	61.4	67.8	NS
Height, cm (median)	168.0 (160.8-175.0)	171.0 (164.0-178.0)	NS
Weight, kg (median)	79.5 (69.8-95.5)	83.0 (73.0-94.3)	NS
Body Mass Index (median)	27.9 (24.5-33.4)	28.2 (25.6-31.7)	NS

Table 2 Fluoroscopy times.

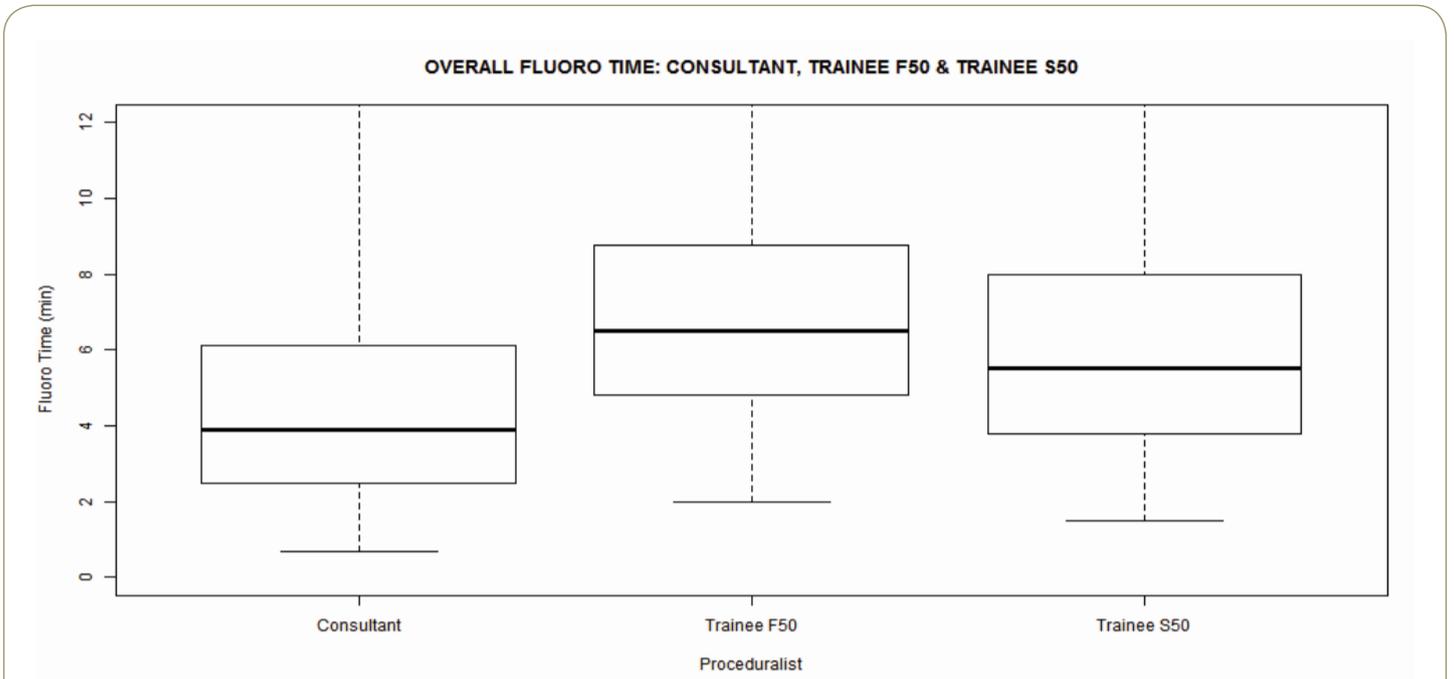
Variables	Consultant (n=567)	Trainee (n=707)	p-value
Radial, min (IQR)	4.5 (2.9-7.0)	6.7 (4.8-9.9)	P<0.0001
Femoral, min (IQR)	3.2 (2.2-4.9)	5.3 (3.9-7.5)	P<0.0001
Total, min (IQR)	3.9 (2.5-6.1)	6.0 (4.2-8.4)	P<0.0001

FT: Fluoroscopy Time; IQR: Interquartile Range

Table 3 Trainee fluoro times

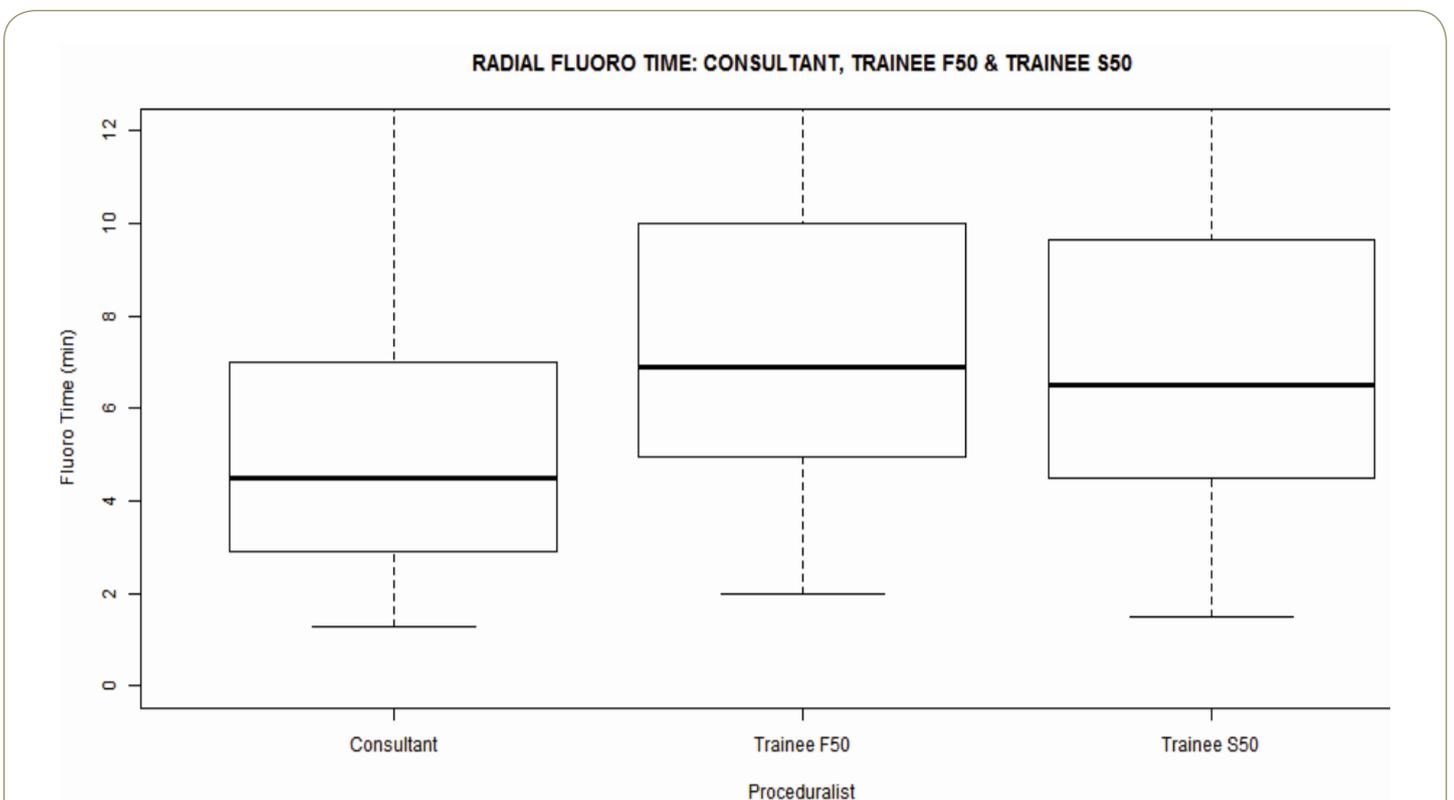
Variables	Trainee F50	Trainee S50	p-value
Radial, min (IQR)	7.1 (5.1-10.3)	6.1 (4.2-8.4)	P=0.0015
Femoral, min (IQR)	5.9 (4.4-7.9)	4.7 (3.5-6.6)	P<0.0001
Total, min (IQR)	6.5 (4.8-8.9)	5.2 (3.7-7.5)	P<0.0001

F50-first 50 cases, S50-second 50 cases; IQR: Interquartile Range.



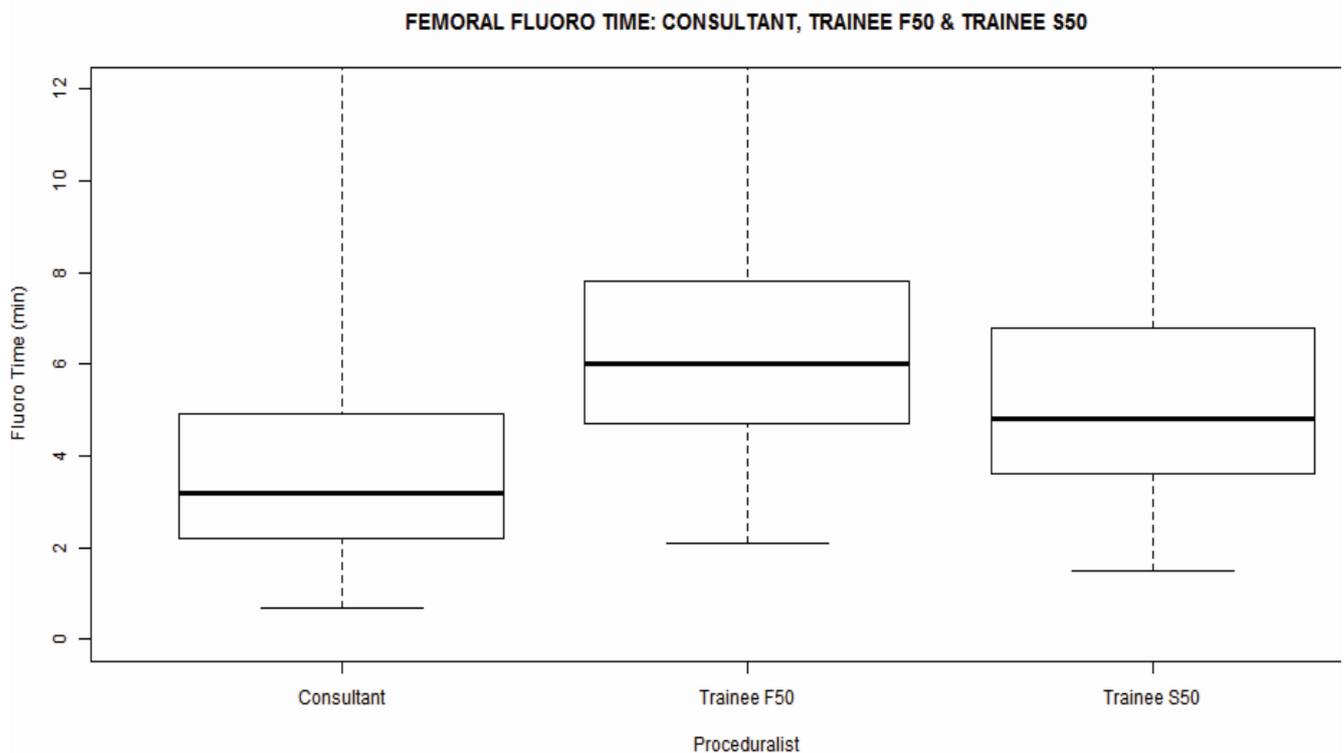
Trainee F50-first 50 trainee cases; Trainees S50-second 50 trainee cases.

Figure 1 Overall fluoroscopy times.



Trainee F50- first 50 trainee cases; Trainees S50- second 50 trainee cases.

Figure 2 Radial fluoroscopy times.



Trainee F50- first 50 trainee cases; Trainee S50- second 50 trainee cases.

Figure 3 Femoral fluoroscopy times.

Using these results, we derived scatter plots to evaluate trainee FT against procedure number, to try to identify trainee “learning curves” for overall, transradial and transfemoral angiography. Trainee FTs appear to decrease with increasing procedure numbers, and this applies for all means of coronary angiography. However, the coefficient correlations for all three scatter plots were not statistically significant, limited by the small sample size (**Figure 4**).

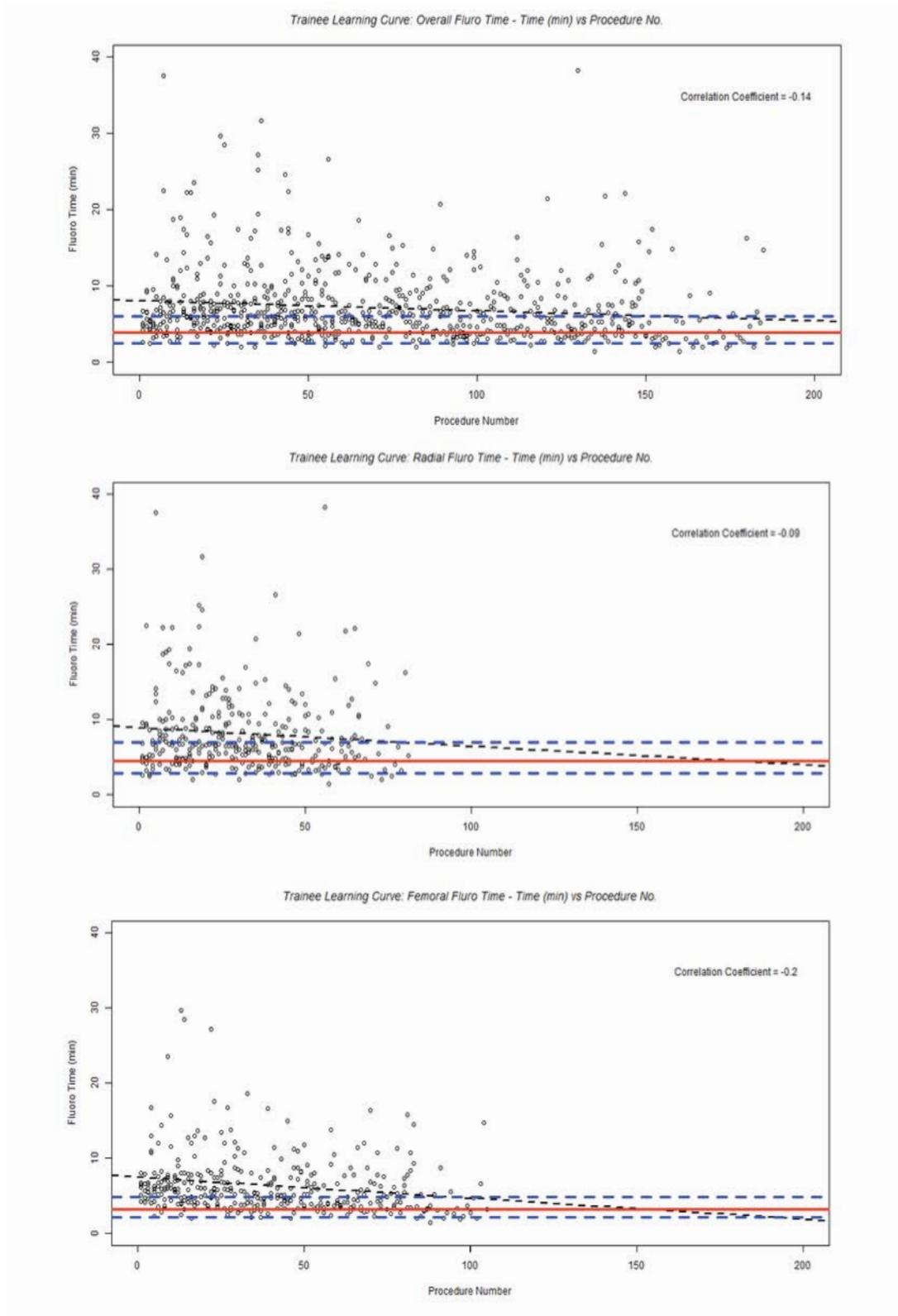
Discussion

In this study, we have demonstrated that cardiology trainees took longer to perform diagnostic coronary angiography than their supervisors. The transradial approach was associated with longer FT, however with increasing experience, trainees were able to decrease this in both transfemoral and transradial approaches. After fifty supervised cases, there was a discernible improvement in total, TF and TR efficiency.

Trainee inexperience has been found to be associated with longer procedure times as assessed by fluoroscopy time [3,4]. Jensen et al determined a caseload of 150 coronary angiographies to obtain competency-defined as a median fluoroscopy time within the IQR of an expert [2]. All trainees in our study had no prior experience with coronary angiography prior to entering into cardiology training. In their first year of training, the trainees’ overall-FT, TR-FT and TF-FT were consistently outside the third-quartile of the supervisors FT. In their second year, median FT

was all within the 50% to 75% interquartile range thus attaining competency as per Jensen’s definition. Although this competency was not consistently met just after 50 cases, at this “cut-off”, a statistically significant improvement in FT was achieved. This is in keeping with the thirty to 150 cases that has been described as the “learning curve” in the transradial approach: 30 to 50 for TF interventional cardiologist to attain TR proficiency [6,7], over 50 cases as per the ESC consensus [5] and as high as 100-150 in certain operators [7].

A caseload-based system of training to attain TR proficiency is likely more fruitful than a time-based system. Castles et al. [8] found a 6-month introductory phase to introduce TR to the catheterization laboratory to have no improvement in FT; likely due to low case numbers (109 cases in 6 months across five experienced cardiologists). Conversely, Looi et al. [9] found that a six-month learning curve to be sufficient in decreasing FT in non-experienced radial operators with a relatively similar caseload (36 procedures per operator in the first 9 months). A potential for the difference in the findings may be related to each centre’s different experience in TR procedures. Vlachadis Castle study was undertaken at a center in the early phase of establishing a TR program with only one TR expert and 4 non-experts, versus in Looi’s center of 3 experts to 5 non-experts. The role of a transradial proctor to help establish TR in a traditional TF center has its appeals, however has never been studied. In our center, the presence of five transradial “experts” may have helped our trainees improve their TR proficiency more quickly.



Legend: ——— consultant fluoroscopy times, - - - - - interquartile range of consultant fluoroscopy times, - - - - - trainee fluoroscopy times.

Figure 4 Overall, radial and femoral trainee learning curves when compared to consultant cardiologists.

Study Limitations

There are several limitations to this study. It is a retrospective, single centre study where the accuracy is dependent on the proper documentation of each procedure. Trainees may have gained some experience in the in-patient catheterization laboratory and so the minimum number of cases required demonstrating equivalence to consultant times may be underestimated. We used fluoroscopy time as a surrogate marker for competence, however no data was collected comparing clinical outcomes or complications. Complication rates for coronary angiography are generally low thus the numbers required to identify a difference are beyond the scope of this study. It is possible that supervisors

may intervene at an earlier stage in the beginning of training. This, however, would likely decrease FT in the first 50 cohort and not invalidate our findings that a significant improvement in FT exists.

Conclusion

This study demonstrates that cardiology advance trainees do have longer fluoroscopy times when compared to consultant cardiologists, in overall, radial and femoral cases. However, these times improve over the course of their training. In addition, we have shown an improvement in transradial coronary angiography is feasible in trainees after at least fifty cases at a transradial cardiac center, with appropriate supervision.

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