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# Has the introduction of an advanced practitioner led service had an impact on radiation dose for fluoroscopy guided lumbar punctures? A service review

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ABSTRACT

*Introduction:* Historically, procedures requiring fluoroscopic guidance such as myelography; barium and video swallows; and fluoroscopy guided lumbar punctures (LP) have been performed by radiologists with the assistance of radiographers. As the National Health Service (NHS) evolves, more responsibilities are being disseminated to specifically trained radiographers to relieve workload due to a national shortage of radiologists. One step taken by the trust was to train an Advanced Practitioner (AP) in fluoroscopy to perform fluoroscopy guided LPs. Clinical audit and service evaluations are required to ensure there is no impact on patient care as a result of changes in practice. Regardless of occupation, healthcare workers undertaking procedures must ensure the same standards of care for patients. Minimising radiation dose is a duty of all radiological professionals.

*Methods:* This retrospective review evaluated and compared examinations performed by a group of radiologists and an AP in terms of dose area product (DAP) and fluoroscopy screening time. A total of 300 X-ray guided LPs doses were reviewed and comparison between the radiation exposure data sets was performed to determine whether there was a significant difference between the two operator groups.

*Results:* The study revealed that AP-performed LPs had a statistically significant lower DAP and fluoroscopy time (a mean of 4.21Gycm2 and 0.74min) compared to the radiologist-performed LPs (a mean of 5.72Gycm2 and 0.94min).

*Conclusion:* The review demonstrates that patient dose is not detrimentally affected by the introduction of an advanced practitioner. It establishes that dose and screening time was significantly lower. It also highlights the effectiveness of APs in an evolving radiology department.

*Implications for practice:* These outcomes propose advanced practitioners in this area of expertise can expand their role from neuroradiographer with no detriment to patient dose. Despite the results, it is recognised that continuous appraisal is required to ensure that competencies are maintained, and high levels of care are sustained.



## Introduction

X-ray, or Fluoroscopy, guided LP have traditionally been performed by radiologists. However, due to the annual increase in radiologist workload,[1] the authors trust decided to train an Advanced Practitioner to perform LP to enable radiologists to concentrate on other duties such as reporting and preparing for multidisciplinary meetings. Advanced practice in radiography was first introduced as part of the National Radiography Services Skills Mix Project.[2] The project identified workload growth, the worldwide shortage of radiologists and the need to develop an effective radiography career pathway as drivers behind the scheme. Advanced Practice roles in radiography are commonly utilised by (NHS) Trusts to combat radiologist shortages. The roles required are often trust dependent. Examples include reporting radiographers in a variety of specialties and Advanced Practitioners undertaking interventional procedures[3] amongst others. The authors trust is a specialised neurological centre and was seeing increased referrals for fluoroscopy guided LP and therefore made the decision to develop an Advanced Practitioner role that would perform these procedures to increase radiologist reporting capacity. Unlike other more established Advanced Practice roles in radiography, no specific training courses were in place for this procedure. Fortunately,

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the department has had previous experience of setting up advanced training and a comprehensive training strategy was formulated which included suitable theory and practical skills coaching. A competency framework, which included protected sessions was agreed and the radiographer commenced master's level postgraduate education in order to facilitate this role and the training plan was established. An annual audit of AP success rate was started from April 2018 which displayed 98.4% success followed by 100% the following year. No data was collected for radiologist success rate, so comparisons are unable to be made.

All regulated radiology professionals have a responsibility to maintain standards set out under the Ionising Radiation (Medical Exposure) Regulations (IR(ME)R) 2017 and “must ensure that doses arising from the exposure are kept as low as reasonably practicable consistent with the intended purpose.”[4] Therefore, it is imperative to review any changes in practice to ensure radiation dose is not disproportionately affected. To follow trust policy, a service evaluation was completed following the trust guidance.[5] Service evaluation is used to investigate aspects of care within the health service and is associated with alterations in systems of care when necessary.[6]

## Aim

To review and analyse the fluoroscopy time and radiation dose, as measured by dose area product (DAP), from a sample of fluoroscopy guided LP's performed by a group of radiologists and perform a comparison against an equally sized sample performed by the AP. This would help to deduce whether the introduction of an AP led service has had any impact on radiation exposure to patients.

## Objectives

1. To compare Advanced Practitioner performed fluoroscopy guided LP with radiologist performed fluoroscopy guided LP in terms of
   a. Total DAP;
   b. Fluoroscopy time.

## Literature review

### *The growing role of advanced practitioners in radiology*

One of the first areas to be identified as an opportunity for radiographers to progress to an advanced role was through independent reporting of X-ray images.[7] The first postgraduate course in this specialty was developed in 1995.[8] Traditionally, all radiographic reporting was performed by radiologists. Allowing advanced practitioners to take on some procedures could therefore result in a decrease in radiologists; workload. Advanced practice was first introduced as part of the national radiography services skills mix project which was published in 2003.[6] This project identified the need on focusing on increasing patient contact within advanced radiographic practice and introducing radiological tasks that could be adopted by the Advanced Practitioners.[9] Procedures routinely performed by radiologists such as barium swallows, arthrograms and image guided biopsies amongst others were taken on by Advanced Practitioners. Reviews in this area found increased job satisfaction and cost effectiveness[10] and established that the changes benefitted patients through the quality of examination, high accuracy and speed of reporting as well as having a positive impact on patient experience.[11–13] With radiology workload typically increasing,[1] one option for (NHS) Trusts is to identify radiological procedures that may benefit in the same way.[14] Considering this, it is therefore reasonable to explore procedures such as X-ray guided LPs as a suitable role for Advanced Practitioners.

### *A background on X-ray guided LPs*

Lumbar Puncture (LP) is a procedure used in the diagnosis and treatment of a number of health conditions. Cerebrospinal fluid (CSF) is collected during an LP and a variety of laboratory analysis are performed on this sample.[15] LP can help in the diagnosis of various neurological conditions such as Multiple Sclerosis (MS); Creutzfeldt-Jakob disease (CJD); and serious bacterial, fungal and viral infections, including meningitis and encephalitis. Therapeutically, LPs are used in measuring and reducing, when necessary, intracranial pressure in Idiopathic Intracranial Hypertension (IIH). Generally, doctors will undertake an LP at the bedside and the principal indication for an X-ray guided procedure is this bedside attempt resulting in failure.[16] Fluoroscopic guidance has the potential to decrease the frequency of traumatic lumbar puncture.[17] A traumatic tap occurs when blood contaminates the CSF sample which can delay or give misleading laboratory results. Typical contributing factors for a failed or difficult LP include obesity, spinal deformity and spinal degeneration.[15] These same factors also increase the difficulty of fluoroscopic guided LP. A large body habitus will make image acquisition difficult. Ligamentous calcification and decreased intervertebral spacing in degenerative spinal conditions will increase the difficulty in navigating the LP needle through such a constrained space. For obese patients, as Hudgins et al.[18] allude to, LPs can become more problematic when the needle length is increased, and landmarks become more challenging to recognise radiographically as a result of the increased subcutaneous fat. An elevated procedural difficulty can extend the time it takes to successfully complete and will inevitably result in an increased screening time and DAP. As this service evaluation was performed retrospectively, procedural complexity and patient size were unable to be compared. However, other comparable data such as patient age and gender were analysed.

### *Dose reduction*

All radiological healthcare professionals have a duty to reduce dose using the “as low as reasonably practicable” (ALARP) principle set out under IR(ME)R guidelines.[4] Ionising radiation can have adverse effects on living cells,[19] so it is imperative to minimise dose wherever possible. There are a several techniques that can be implemented to ensure dose is kept to a minimum level. Techniques include the use of pulsed fluoroscopy; geometric and electronic magnification; altered dose level settings and adjustment of beam quality with various filters amongst others.[20] Using pulsed fluoroscopy as opposed to continuous fluoroscopy can reduce screening time and dose by as much as 76% and 64% respectively.[21] Image magnification can be a useful tool during a fluoroscopic examination. Increasing the magnification of the target area can ease the technical difficulty of a procedure although both geometric and electronic magnification increases DAP.[20] The importance of this will need to be present and constantly ascertained in the operators; minds. Reducing geometric magnification by increasing source-to-image distance can help keep entrance skin dose minimal.[19] Knowledge of filter settings and capabilities of fluoroscopy systems are crucial in keeping DAP and screening time as low as practicable. The above dose reduction techniques highlight the importance for operators to have specialised training in the appropriate use of radiation.[20] Radiation protection is a

| Group Statistics | | | | | |
|---|---|---|---|---|---|
| | Profession | N | Mean | Std. Deviation | Std. Error Mean |
| Dose Gycm² | Radiologist | 150 | 5.7193 | 6.70999 | .54787 |
| | A.P. | 150 | 4.2102 | 3.47670 | .28387 |
| Screening Time (mins) | Radiologist | 126 | .941 | .7940 | .0707 |
| | A.P. | 132 | .737 | .4829 | .0420 |

**Figure 1.** Mean, Standard Deviation and Standard Error Mean of the two variable groups.

fundamental requirement and core duty for radiographers and radiologists.[22] Radiographers undergo formal training in this area prior to graduation and therefore have a foundation of knowledge which is useful in advanced practice. Research shows that APs taking on procedures traditionally performed by doctors, allows more time for doctors to focus on other work and the increased autonomy benefits both staff and patients.[11] For this to be achieved, it is important that training is accompanied by strict protocols and competency review as well as undertaking regular audits.[23] Some studies have shown that radiographer delivered fluoroscopy can result in a reduced patient dose.[24,25] However, evidence of this is sparce and occasionally outdated.

## Methodology

### *Study design*

The methodology used was purely quantitative. Screening time and DAP is recorded as a numerical reading making it straightforward to collect large amounts of information for statistical analysis without any requirement to quantify outcomes. The quantitative method was deemed to be more suitable in this instance as the process can be easily reproduced in the future. It is also useful as there is a measurable objective for this service evaluation.[26] The trust audit panel reviewed the proposal and study design and, along with the trusts research department, gave consent to proceed with the service review. As this was a service evaluation in nature, it did not require full ethical consideration as there would be no retrospective change to patient management.

### *Data collection*

The data was collected retrospectively using the departments computerized database of radiographic events: Clinical Radiology Information System (CRIS). The screening time and DAP for patients undergoing X-ray guided LP between 09/2016–10/2019 were collated. 25 procedures were excluded as they were performed by training radiologists or AP. A total of 300 studies were selected for

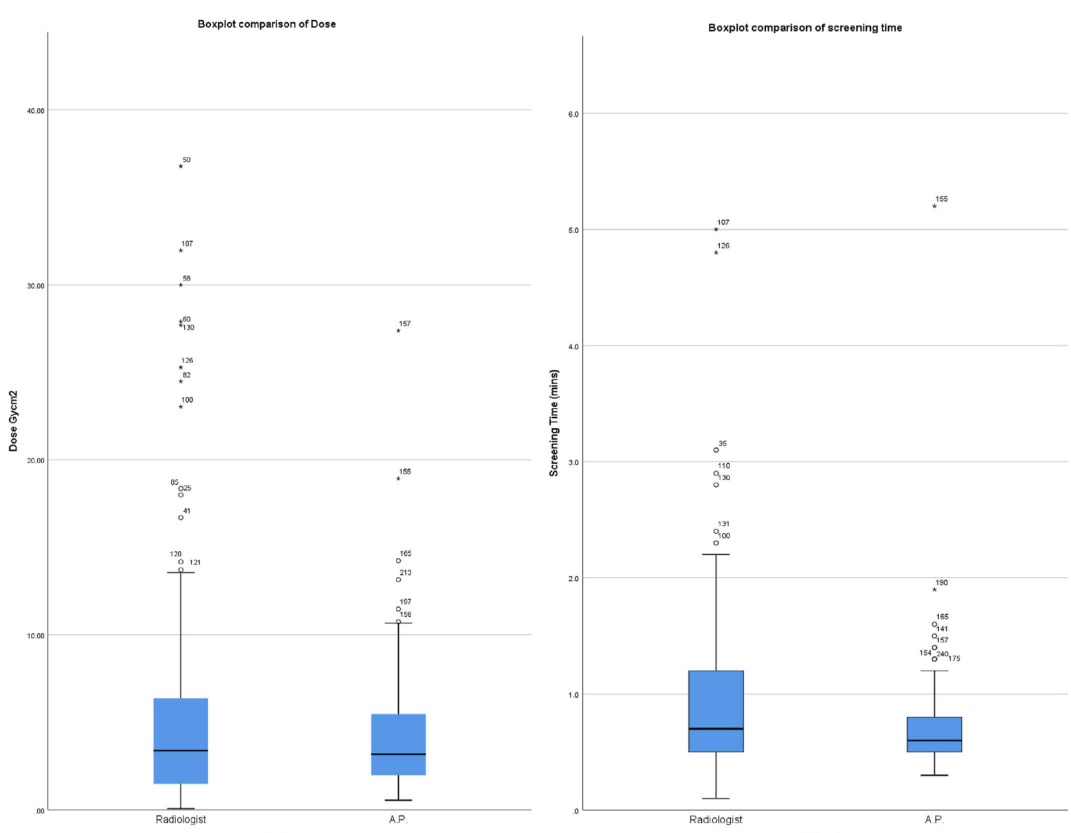


**Figure 2.** Boxplot comparing Mean DAP and screening time of the two variable groups.

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Dose Gycm2 | Equal variances assumed | 23.119 | .000 | 2.446 | 298 | .015 | 1.50907 | .61704 | .29476 | 2.72339 |
| | Equal variances not assumed | | | 2.446 | 223.624 | .015 | 1.50907 | .61704 | .29311 | 2.72504 |
| Screening Time (mins) | Equal variances assumed | 24.044 | .000 | 2.508 | 256 | .013 | .2041 | .0814 | .0438 | .3645 |
| | Equal variances not assumed | | | 2.481 | 204.523 | .014 | .2041 | .0823 | .0419 | .3664 |

**Figure 3.** Independent samples T-Test.

analysis, the relevant data were collated, the data was entered into an anonymised database. 150 LP were carried out by either a consultant radiologist or radiology registrar and 150 LP were carried out by the Advanced Practitioner following the completion of their training. All examinations were performed using a Toshiba Ultimax-I fluoroscopy suite to maintain continuity and reliability. The DAP was recorded using the dose report on the Trust's Picture Archiving and Communication System (PACS). Fluoroscopy time was recorded on CRIS by the radiographer. Screening time was not recorded in 24/150 (16%) LP performed by the radiologist and 18/150 (12%) LP performed by the Advanced Practitioner and were excluded from analysis. The patients' age and gender were also analysed retrospectively to determine whether there were any fundamental differences between the groups that may affect the results.

## Results

The data was recorded analysed using IBM SPSS version 26. The procedures that had no fluoroscopy time entered in CRIS were excluded from variable analysis.

As evidenced by Figs. 1 and 2, the mean DAP for radiologist-performed LPs from this sample was 5.72Gycm$^2$ compared to 4.21Gycm$^2$ from the sample performed by the Advanced Practitioner. The Advanced Practitioner group also demonstrated a lower mean screening time at 0.74 min as opposed to 0.94 for the radiologist group. There is also a significantly lower standard deviation for both sets of data in the AP group. Fig. 2 shows a decrease in range for the AP in comparison the radiologist in both DAP and screening time.

The assumption of homogeneity of variances was violated both for dose and screening time (as per Levene's test ($p < 0.001$)). Mean dose was 1.51 Gycm2 (95% CI, 0.29 to 2.73) higher in radiologists when compared with Advanced Practitioner's dose. This difference was statistically significant ($t(223.62) = 2.45$, $p = 0.015$). Screening time was 0.2 min (95% CI, 0.4 to 0.37) higher in radiologists when compared with Advanced Practitioner's dose. This difference was statistically significant ($t(204.52) = 2.48$, $p = 0.014$). These values are displayed in Fig. 3.

There was a total of 300 patients included in the study. In the radiologist group 50.7% of patients were females while in the Advanced Practitioner group it was 49.3%. There was no statistical difference as assessed by the Fisher's exact test, $p = 0.614$. There was also no statistical difference in the mean age of patients between the two groups (Radiologist 47.05 yrs, AP 46.37yrs) as assessed by the independent samples t-test, $p = 0.735$.

Fig. 4 demonstrates the regularity at which LP were performed and the gradual uptake of procedures performed by the AP. It also shows the steady annual increase in the number of referrals.

## Discussion

Forty-two (14%) of the fluoroscopy time results were excluded from the data analysis as they were not recorded onto the radiology system. The samples were taken from 2016 - 2019.

| Staff Group | 09/2016 - 08/2017 | 09/2017- 08/2018 | 09/2018 - 08/2019 |
|---|---|---|---|
| Radiologist | 81 | 55 | 15 |
| A.P. | 9 | 51 | 113 |

**Figure 4.** Total number of LPs performed per year (including training).

The mean DAP and screening time for AP-performed LPs were significantly below that of the radiologist-performed LPs with a significance of ($p = 0.015$) and ($p = 0.013$) respectively. Consideration must be given to the fact that repetitive practice increases competence of the operator.[27] Once the implementation of the Advanced Practitioner was completed, regularity of radiologist performed procedures decreased as shown in Fig. 4. This could be a factor in the results displayed. The lower standard deviation for both measurements in the Advanced Practitioner group shown in Figs. 1 and 2 may suggest a more consistent procedural approach. However, this could be explained as there was only a single AP as opposed to several radiologists which could also account for the lower dose and reduced exposure time with less outliers. It would be unprecedented for all the radiologists to be at the exact same competency levels and a greater deviation from a standard technique is expected.

It is important to consider whether different levels of radiation protection awareness could be a factor in these results. Objectively, radiologists and radiographers learn about radiation protection and safety and may be taught across a very similar timeframe. However, a radiographers training will generally take 3–4 years as opposed to 13–15 years of training to become a consultant radiologist. Therefore, the same training forms a much higher percentage for radiographers hence a greater significance in application. Also, once qualified, most of the radiologists' time will be taken up with reporting. Whereas, a radiographer will spend much of their occupation working with radiation, so dose reduction and radiation protection becomes more pertinent. Therefore, the prevalence and awareness of radiation reduction and safety entails a larger proportion of the radiographers; role. However, there is inadequate research in this area.

### *Limitations*

This service evaluation covers a single centre and is limited in suggesting effectiveness as many positive findings are overstated when researched in subsequent multi-centred studies.[28] Observations from single centre studies can prove difficult to reproduce due to the lack of scientific rigour of large multi-centred research.[28] Correspondingly, service evaluations can be beneficial in maintaining high levels of patient care[29] and are a powerful tool to improve and evaluate healthcare outcomes but there are many barriers in demonstrating reliability and validity. There is currently only one practicing AP in the trust thus it is challenging to gauge whether results would be reproducible. Further evaluation across multiple centres would be beneficial to validate the practicability of role expansion in this field.

Fluoroscopy time data in this evaluation was reliant on the correct input onto the CRIS system by the processing radiographer. This introduces human error into analysis. For example, a total of 42 fluoroscopy time datasets were incomplete and were removed from the findings and suggests some degree of input error.

Other limitations include the retrospective approach. No other data could be collected that may have an impact on individual doses such as patient size or technical difficulty. A prospective method would allow for these factors to be considered.

## Conclusion

The results of this service evaluation show that there was a positive impact on patient dose following the introduction of an AP led service. These outcomes propose Advanced Practitioners in this area of expertise can expand their role from neuroradiography with no detriment to patient dose. Literature suggests promising positive development of radiographers into different areas of advanced practice[2,12] if conducted by sufficiently trained personnel. However, this is limited due to relative size of studies. Financial benefits in areas of advanced practice are demonstrated[9] yet other aspects of care such as patient outcomes; patient satisfaction; patient dose and continuity of care are rarely measured. More robust research in this area is needed to highlight positive impacts of Advanced Practitioners. The recent report for the Council of Deans[14] highlights the work being done to optimise education programs to further enhance the role. It illustrates that advanced clinical practice needs to grow to meet the continuing health demands of the population.

## Conflict of interest statement

None.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2021.04.003.

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