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Undergraduate radiology education: foundation doctors' experiences and preferences

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AIM: To assess foundation doctors' experiences of undergraduate radiology teaching within the UK and preferences for radiology teaching delivery.

MATERIALS AND METHODS: This was a retrospective multicentre study of foundation doctors. A questionnaire, designed using the Royal College of Radiologists Undergraduate Radiology Curriculum, was completed to determine how prepared foundation doctors felt in image interpretation by their undergraduate teaching. For this, agreement with statements was graded using a five-point Likert scale. Open and closed questions were used to assess preferences for teaching delivery.

RESULTS: The study involved 150 foundation doctors from 29 medical schools. The majority "strongly agreed" or "agreed" that undergraduate training gave them confidence in interpreting most basic chest and abdominal radiographs. Confidence was less for skeletal radiographs and trauma computed tomography (CT). Seventy-seven percent wished they had had more radiology teaching. The three most important topics to be included in teaching were chest radiograph, CT, and abdominal radiograph interpretation. Small group teaching and integration into clinical teaching received the highest number of votes for preferred teaching delivery method. Ninety-two percent felt radiologists were best suited to deliver teaching.

CONCLUSION: In general, foundation doctors felt undergraduate teaching prepared them well for chest and abdominal radiograph interpretation, but less so for skeletal radiography and CT. The majority felt more undergraduate radiology teaching would be beneficial, and that this should be delivered by radiologists in either small group sessions or integrated into clinical teaching.

Introduction

Imaging plays an integral role in patient care and the reliance on imaging continues to increase rapidly.[1] Despite this, undergraduate radiology education in the UK has received relatively little attention in the literature over many years and is highly variable at universities.[2] The prevalence of radiology in undergraduate medical curricula also varies widely in Europe.[3] Within the existing literature, there has been debate over what, when, and how radiology should be taught at undergraduate level in the UK.[4,5] Only recently has some sort of consensus been reached with the

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publication of the Royal College of Radiologists (RCR) Undergraduate Curriculum.[6,7]

The GMC's "Outcomes for graduates" document sets out the knowledge and skills that medical school graduates should attain in the UK.[8] This states that graduates should be able to "interpret the results of investigations, including X-rays"; however, it has been shown that medical students and junior doctors struggle to interpret simple radiographs.[9–11] This emphasizes the need to integrate radiology into undergraduate medical training. It is vital to train medical students to interpret basic radiographs, not only to alleviate the pressures on the radiology department, but also so that timely, effective and safe care is delivered to patients.[4,10,12]

Acknowledging the lack of research in identifying necessary radiological content for undergraduate medical training, Misradraee *et al.* (2012) performed a study to identify these using a Delphi study of experts in undergraduate radiology education.[10] The information gained from this study formed the basis of the Undergraduate Radiology Curriculum (URC) published by the RCR of UK in 2012.[5,6] A revised version was published more recently in 2017[7]; however, despite publishing these, a recent study revealed that only 78% of medical schools were aware of it and following its recommendations.[2]

The RCR's URC (2017) states that its aim is to prepare "foundation doctors with the necessary knowledge and skills to routinely arrange and correctly interpret basic radiological investigations in the context of the individual patients, with understanding of applicability, limitations and impact on patient safety".[7] Even though the aim is to prepare for foundation training, the most influential literature leading to and assessing the URC have focused on the opinions of consultants and medical students.[5,10] No study to investigate these factors has been published investigating foundation doctors.

Within the UK, foundation doctors are doctors within the first 2 years after graduation. They are in the unique position of having very recently been through undergraduate medical training, as well as presently working at the level that the URC is designed to prepare for. Arguably, this puts them in the best position to provide advice and assess the quality of undergraduate radiology education. The present study was undertaken to assess the foundation doctors' experiences of undergraduate radiology teaching within the UK, as well as their preferences for how this teaching should be delivered and what should be included.

Materials and methods

Recruitment

This is a retrospective and multicentre study investigating foundation doctors working within four NHS trusts. All foundation doctors were working within a single training deanery. They attend compulsory local teaching at their base hospital. Attendance at approximately 70% of these sessions is a pre-requisite to completing foundation training, and so they are generally well attended. An author would attend one of these sessions to ask them to anonymously complete a questionnaire. This was thought the best way to maximize response rate, as electronic forms are generally not well completed.[13] The study was performed towards the end of their foundation year (2017), in order to allow enough experience as a foundation doctor to reflect upon. Both foundation Year 1 and 2 doctors were included in this study. Only those who attended medical schools in the UK were included.

Ethics

Ethics approval was deemed not required by an NHS Trust Research and Development department, as this project was deemed to be a satisfaction/training needs type of survey.

Questionnaire

The questionnaire comprised three main parts (Electronic Supplementary Material Appendix S1). The first part identified basic information. This included their year of training and the university attended. On the questionnaire it stated that this information would not be used to assess each university's performance.

The second part subjectively assessed how well their undergraduate medical training prepared them for image interpretation. Teaching of the fundamental principles of radiology (e.g. radiation protection, risks, appropriate requesting) was also assessed. Agreement with statements were graded using a five-point Likert scale (strongly agree = 5; agree = 4; neither = 3; disagree = 2; strongly disagree = 1). This section was designed to closely follow the RCR's URC,[7] and so included assessments of the three main sections of the curriculum: "Fundamental principles", "Common emergency conditions" and "Imaging in other common presentations". This allowed an assessment of how well URC content is currently taught at medical schools.

The third part investigated how their undergraduate radiology teaching was delivered, as well as their perception of the teaching they received. Also explored were their preferences as to how undergraduate radiology teaching should be delivered. A mixture of open and closed questions was used.

Statistical analysis

Data were analysed using Microsoft Excel (version 14.6.6). Simple statistical analyses (e.g., totals and percentages) were performed on the data for the first and third parts of the questionnaire. For the second part of the questionnaire, agreement with statements was assigned a value according to a Likert Scale (strongly agree = 5; agree = 4; neither = 3; disagree = 2; strongly disagree = 1). A mean value for each question was subsequently calculated.

Results

Part 1

A total of 150 foundation doctors completed the questionnaire. This included 95 foundation Year 1 doctors from four NHS trusts and 55 Year 2 doctors from three NHS trusts. A maximum of 312 doctors could potentially have completed the questionnaire, giving an overall response rate of 48.1%. This included doctors from 29 medical schools within the UK. Unfortunately, in one NHS trust, there lacked an opportunity to approach foundation Year 2 doctors at their teaching. This is the reason for including only three trusts in this year group. An attempt to receive responses for this group was made through email, but no responses were received. This group was therefore excluded from the study.

For incomplete questionnaires, any answers provided were included in the analysis as they were still deemed to provide useful information. One hundred and forty-six (97%) questionnaires were completed in full.

Part 2

The results for this section are detailed in Table 1. Values provided for each Likert value correspond to the number doctors who provided that answer. "Confidence" was defined as a mean Likert score >3, as this includes those who "strongly agreed" or "agreed" with the statements.

Foundation doctors demonstrated confidence in recognizing normal structures on plain radiographs and CT. The mean Likert score was <3 for magnetic resonance imaging (MRI) and ultrasound. They also demonstrated confidence in interpreting chest, abdominal, upper limb, and lower limb radiographs. The mean Likert score was <3 for spine and paediatric radiographs. Confidence was demonstrated in identifying 80% of chest radiograph, 83% of abdominal radiograph, 50% of skeletal radiograph and 17% of major trauma CT pathologies stated in the URC. Confidence was also demonstrated in choosing the most appropriate investigation for their patient. Mean Likert scores for "Fundamental principles" was >3 for 89% of questions. It was <3 for receiving teaching in "How images are obtained".

Part 3

Forty-nine percent (74/150) of foundation doctors either "agreed" or "strongly agreed" that radiology was well taught at medical school. Sixty-nine percent (104/150) of foundation doctors "agreed" or "strongly agreed" that medical school prepared them well to interpret basic imaging required in the acute setting as encountered in their foundation years. Seventy-seven percent (113/147) wished they had had more radiology teaching. In fifty-seven percent (85/150) of cases, foundation doctors had received radiology teaching approximately once per month or more frequently. Ninety-three percent (137/148) of foundation doctors believed that they should receive radiology teaching once per month or more frequently. Table 2 demonstrates the breakdown of results.

Table 3 demonstrates the most important radiology-related teaching topics as voted for by the foundation doctors. The preferred methods of teaching delivery most frequently ranked in the top 3 were "Integration with clinical teaching (i.e. within a clinical environment) as part of clinical decision-making process", "Small group 'hot seat' tutorials", and "Integration into lectures/tutorials on other modular topics". These received 120, 119, and 74 top 3 votes, respectively. Forty-seven percent (69/148) of foundation doctors had spent time in a radiology department as an undergraduate. Of those, 65% found the experience either "very" or "somewhat" useful.

The personnel most appropriate to deliver radiology-related teaching that were most frequently ranked in the top 3 were "Radiologist (consultant and trainees)", "Junior doctor (non-radiology)," and "Non-radiologist clinical consultants". These received 141, 98, and 92 top 3 votes, respectively.

Table 4 demonstrates the radiology-related topics that the foundation doctors wished they had more exposure to in their undergraduate teaching. This question was included to identify the deficiencies of current undergraduate teaching, rather than just identifying important topics to teach, which Table 3 is designed to show. Thirty percent of the foundation doctors answered either "yes" or "maybe" when asked whether they were considering a career in radiology. The remainder were not.

Discussion

Radiology is a specialty that has driven continued improvements in medicine by embracing advancements in technology.[14] Other specialties have become heavily reliant on it, resulting in a massive increase in workload, which the radiology workforce is struggling to cope with.[1,15,16] At times, it can take weeks for a plain radiograph to be reported.[17] It is therefore imperative that junior doctors are given the skills to interpret these investigations in the acute setting to maintain safety within the clinical environment.

As the experts in image interpretation, it is important for radiology as a specialty, to provide guidance on how to optimize undergraduate radiology education. Within the UK, the RCR's URC is aimed at doing this. One published study has evaluated the URC to date.[5] This was a single centre study of medical students using the first iteration.[5,6]

Foundation doctors are arguably best placed to assess undergraduate radiology training. Not only have they recently completed medical school, but they also have current experience of working at the level of doctor the URC is aimed to prepare for. Medical students have not completed undergraduate training, making it difficult for them to assess training geared towards a level not yet attained. This is a major disadvantage of an existing study that assessed preclinical medical students.[5] The study by Misradraee *et al.* (2012), which appears to have heavily influenced the URC, advised that many of its recommendations should be included in the "clinical years of the curriculum, and not during the basic medical sciences".[10] Therefore, in order to

Table 1
Results of Part 2 of the questionnaire.

Question	Strongly agree (5)	Agree (4)	Neither agree or disagree (3)	Disagree (2)	Strongly disagree (1)	Mean Likert value
As a junior doctor, I feel my medical school training gave me confidence in recognizing normal structures on:						
Plain radiographs	57	83	5	5	0	4.2
CT	6	63	38	33	10	3.1
MRI	1	25	38	62	24	2.4
Ultrasound	1	4	17	66	62	1.8
As a junior doctor, I feel my medical school training gave me confidence in interpreting the following:						
Chest radiographs	66	80	3	0	1	4.4
Abdominal radiographs	36	88	21	4	1	4.0
Upper limb radiographs	5	61	48	32	4	3.2
Lower limb radiographs	5	65	44	32	4	3.2
Spine radiographs	1	23	35	71	20	2.4
Paediatric radiographs	1	6	24	62	57	1.9
As a junior doctor, I feel my medical school training gave me confidence in identifying/assessing the following:						
Chest radiograph						
Misplaced nasogastric (NG) tube	29	72	17	26	6	3.6
Misplaced endotracheal (ET) tube	4	34	22	61	29	2.5
Misplaced central venous catheter	4	9	22	70	45	2.0
Simple/tension pneumothorax	79	66	2	2	1	4.5
Pleural effusion	84	61	4	0	1	4.5
Lung/lobar collapse	54	82	12	1	1	4.2
Lung consolidation	80	66	4	0	0	4.5
Heart failure	63	78	9	0	0	4.4
Foreign body	44	72	22	10	2	4.0
Pneumoperitoneum	69	60	11	9	1	4.2
Abdominal radiograph						
Small bowel obstruction	53	84	9	4	0	4.2
Large bowel obstruction	52	83	11	4	0	4.2
Toxic megacolon	26	83	32	7	2	3.8
Pneumoperitoneum	44	73	20	11	2	4.0
Foreign body	28	78	32	10	2	3.8
Common causes of normal and abnormal calcification	8	34	45	49	14	2.8
Skeletal radiograph						
Bone fractures	18	95	23	12	2	3.8
Pelvis	11	72	36	29	2	3.4
Femoral neck	21	92	25	10	2	3.8
Wrist/carpus/scaphoid	4	38	51	51	6	2.9
Long bones	10	84	26	28	2	3.5
Fractures involving joint/epiphyseal plate	2	33	40	61	14	2.7
Joint dislocation	3	67	50	23	7	3.2
Joint effusion	3	21	36	73	17	2.5
Lipohaemarthrosis	2	15	24	71	38	2.1
Fracture/dislocation of spine	1	17	35	63	34	2.3
Major trauma CT						
Head injury	15	82	23	21	9	3.5
Bone and soft-tissue trauma	5	29	43	56	17	2.7
Spinal injury	3	7	31	77	32	2.1
Thoracic injury	1	11	35	75	28	2.2
Abdominopelvic trauma	2	12	26	81	29	2.2
Acute vascular injury	4	7	22	78	39	2.1
Generally, I feel comfortable in choosing the most appropriate investigation for my patients	10	123	13	0	0	4.0
Through my medical school education, I received teaching/training in:						
The basic principles of radiation protection	16	83	16	29	5	3.5
The doctor's role in limiting risk of radiological examinations to patients	19	89	22	18	1	3.7
The risks associated with different investigations (e.g., plain radiographs, CT, MRI, ultrasound)	25	94	20	10	0	3.9
The risks of contrast media	19	87	27	13	3	3.7
The importance of requesting basic imaging in a timely fashion	30	105	11	2	1	4.1
The importance of providing relevant and accurate information when requesting investigations	39	93	11	5	1	4.1
How images are obtained (e.g., spending time with radiographer)	12	40	37	47	13	2.9
Understanding the role of consent in a radiology department	11	46	43	42	7	3.1
Understanding the role of the radiologist	13	80	36	16	4	3.6

Table 2
Frequency of radiology teaching received and recommended by foundation doctors.

	Weekly	Fortnightly	Monthly	Quarterly	Less than quarterly	Never
Received	13%	17%	27%	25%	18%	1%
Recommended	31%	33%	28%	7%	0%	0%

gauge how well URC content is taught at medical school, the clinical years must be included.

The foundation doctors felt that their undergraduate radiology teaching gave them confidence in interpreting chest, abdominal, upper limb, and lower limb radiographs. Confidence was less with spine and paediatric radiographs. The mean Likert scores for chest and abdominal radiographs were considerably higher than demonstrated by Jacob *et al.* (2016).[5] The reason for this difference is likely multifactorial, and includes the differences in level of training. It is also possible that they found it difficult to differentiate their confidence at end of medical school to their present status. Despite the wording of the question being explicit, this may have led to overestimation in confidence.

Foundation doctors also appeared confident that their undergraduate radiology training prepared them to identify the majority of emergency conditions on chest and abdominal radiographs. They were noticeably less confident with skeletal radiographs, and even more so for major trauma CT. This suggests that undergraduate teaching concentrates on chest and abdominal radiograph interpretation, which may not be unreasonable, and in fact correlates with two of the top three most important topics that should be taught as defined by the foundation doctors. Skeletal radiographs and major trauma CT are mostly encountered during emergency department attachments, which generally account for a smaller proportion of foundation training. Nevertheless, these techniques should not be neglected. These results suggest that more frequent and improved teaching in these areas is necessary to meet the standards of the URC. An attempt must also be made to improve identification of chest and abdominal radiograph pathologies demonstrating least confidence (e.g., “misplaced endotracheal tube”, “misplaced central venous catheter”).

The foundation doctors generally felt that the fundamental principles of radiology were covered well at medical school. Mean Likert scores were higher compared to Jacob *et al.* (2016) for teaching of “The importance of requesting basic imaging in a timely fashion” and “The importance of providing relevant and accurate information when requesting”.[5] Again, this may be a reflection of the difference in stage of training, as these are clinically focused principles. Comparable scores were noted for “Understanding the role of consent” and “Understanding the role of the radiologist”. Lower scores were demonstrated for “The risks associated with different investigations” and “How images are obtained”. These topics can be easily included into pre-clinical teaching and so may explain these comparable and lower scores.[5] It is important to emphasize that an understanding of the fundamental principles must not be underestimated, as foundation doctors encounter issues involving many of these topics in their day-to-day work.[10]

An important difference between this and the previous study is this is a multicentre study involving graduates from a large number of universities.[5] Differences in results are partly explained by variation in URC content being taught between universities. Some topics may also be better taught at one university compared to another. This study, therefore, gives more of a general overview of current practice at medical schools in the UK.

Less than half of the foundation doctors believed that radiology was well taught at medical school, and the majority wished they had more teaching. This indicates room

Table 3
Most important radiology-related teaching topics that should be taught at medical school ranked in order of most votes by foundation doctors.

Rank	Topic	No. of votes
1	Chest radiograph interpretation	131
2	CT interpretation	122
3	Abdominal radiograph interpretation	111
4	Risks	77
5	Appropriate requests/indications	66
6	Musculoskeletal plain film interpretation	52
7	Common acute imaging and findings	22
8	Science/practicalities of imaging	20
9	MRI interpretation	14
10	Consent	11
11	Ultrasound scan interpretation	8
12	Spine radiograph interpretation	6
13	Plain film anatomy	4
14	Ultrasound skills	4
15	Echocardiogram interpretation	2
16	Interventional radiology	1
17	Radiology reporting	1

Table 4
Top 15 radiology-related topics that foundation doctors wished they had more exposure to.

Rank	Topic	No. of votes
1	CT interpretation	49
2	Chest radiograph interpretation	25
3	Abdominal radiograph interpretation	22
4	MRI interpretation	21
5	Musculoskeletal plain film interpretation	17
6	Appropriate requests/indications	11
7	Ultrasound scan interpretation	11
8	Common acute imaging and findings	9
9	Risks	9
10	More regular teaching	8
11	Observership	5
12	Consent	4
13	Plain film interpretation in general	3
14	Science/practicalities of imaging	3
15	Clinically based radiology teaching	2

for improvement, and that quality radiology teaching is needed and sought after.[18] Deficient radiology education is not confined to the UK. The European Society of Radiology (ESR) has identified it as an issue, recently making it a priority.[4,19] In New Zealand, only 42% of medical students believed they had adequate radiology teaching.[20] Medicine is becoming more complex, and with this the undergraduate medical curriculum is becoming extremely crowded.[4,10] Topics face increasing competition to be included and have sufficient time allocated to them.[4] It often feels the importance of radiology teaching is underappreciated and underrepresented.[4,10,21] This is counter-constructive considering the exponential rise in imaging volume, without an adequate increase in radiologists.[1,16] The RCR recently described the current climate as an "increasingly desperate situation".[22] Clinicians can wait weeks for a report, and so the ability of junior doctors to interpret basic imaging is ever more important.[17] In 2003, Roger (2003) issued a "call to arms" to stamp out "imaging illiteracy", by encouraging radiology departments to become more involved in education.[4,23] This still holds true today, and this profession needs to drive this change. Radiology training improves ability to interpret imaging[24]; however, we must not only provide more teaching, we must ensure the quality of it is high. Current undergraduate radiology teaching is often "unstructured and inadequate".[5,18,25] This is perhaps the biggest challenge. Only through quality teaching can we expect to maximize the foundation doctor's ability to interpret imaging.

The top 3 radiology-related topics thought most important for undergraduate teaching and the topics they wished for more exposure to were the same, albeit in a different order. This infers that not only do they feel that these topics are important, but undergraduate teaching is also deficient in these areas. CT interpretation was what they most wished for more exposure to, but was the second most important topic. This perhaps implies a greater teaching deficiency in CT than for chest radiographs. Another study identified chest, abdominal, and musculoskeletal radiograph interpretation as their most important topics, which is similar to this study.[26] CT interpretation was not in their top 5 topics, which may reflect the dynamic nature of radiology, and the increasing reliance and ease of access to CT imaging.[15] It may also imply that undergraduate radiology teaching is outdated, emphasizing the need for continued revision of content so that it reflects current priorities in healthcare. This suggests the need for continued re-assessment and revision of the URC. The recent inclusion of CT interpretation in the URC may be a reflection of this; however, unlike with radiographs, radiologists often report CT promptly, and so one may argue whether foundation doctors really require this skill.[17]

The two most preferred methods of teaching delivery were also identified by Jacob *et al.* (2016).[5] Integration with clinical teaching is, understandably, the most popular, as this gives the it clinical relevance and most similar to clinical practice. Unfortunately, it can be more difficult to implement, as it requires cross-specialty coordination, and can be time-consuming to prepare for. Radiologists also seldom work in the clinical environment.[10] Nevertheless, this style of teaching is widely recommended, and so an attempt must be made to try to accommodate this as much as possible.[4,10,27] It should also be noted that good teaching is multi-faceted, and evidence suggests that radiology teaching should ideally be interactive and delivered in small groups.[5,28,29] Self-directed learning is not favoured.[30]

This study, together with previous studies and the ESR strongly support the use of Radiologists for radiology teaching.[10,30] One study, however, has identified medical demonstrators as the most appropriate.[5] Teaching should be delivered by a "competent and credentialed" individual.[10] Radiologists fit in this category as they have the greatest image interpretation experience. Unfortunately, with the increasing workload and national shortage of radiologists, it is increasingly difficult for them to find time to teach.[1,4,10,16]

Less than half of the foundation doctors spent time in a radiology department as a student. Just under two-thirds found the experience useful. This may, in part, explain why less than a third were considering a career in radiology. It has been shown that exposure to radiology improves attitudes towards the specialty and increases interest in pursuing it as a career.[31,32] Therefore, more must be done to ensure positive exposure to this specialty.

The limitations of this study include that it is retrospective; however, a prospective study is not possible as completion of undergraduate training and a period of foundation training was deemed necessary. It is also a subjective study, and so does not objectively measure whether URC standards are met. Care must be taken not to presume competence from confidence, as there may not be a correlation.[5] A future study objectively measuring their ability to interpret imaging, to correlate with subjective confidence should be considered.

To the authors' knowledge, this is the largest study assessing the current state of undergraduate medical training against the RCR's URC. It is the first to compare against the latest URC, and the first to use foundation doctors as the subjects.[7] Generally, foundation doctors felt their undergraduate training gave them confidence in interpreting chest and abdominal radiographs, suggesting that good teaching is being delivered in these areas. The study also helps to identify areas of deficiency, allowing those who teach undergraduate radiology to identify topics that require more focus. Overall, foundation doctors felt more undergraduate radiology teaching would be beneficial, and that this should be delivered by radiologists in either small group sessions or integrated into clinical teaching. It is authors' opinion that, because of their stage in career, foundation doctors can provide invaluable input in how undergraduate radiology education should be delivered, and so any collaboration in developing a curriculum should ideally involve them.

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Conflict of interest

No conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.crad.2019.01.029.

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