A retrospective review of justification of computed tomography examinations in Northern Ireland

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Public Health England
Wellington House
133-155 Waterloo Road
London SE1 8UG
Tel: 020 7654 8000
www.gov.uk/phe
Twitter: @PHE_uk
Facebook: www.facebook.com/PublicHealthEngland

Prepared by: Medical Exposures Group, Public Health England
For queries relating to this document, please contact:MedicalExposures@phe.gov.uk

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Executive summary

As part of its programme of assessing compliance with the Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2000[1], the Regulation and Quality Improvement Authority asked Public Health England to undertake a retrospective review of the justification of computed tomography (CT) examinations in Northern Ireland. The aim of the study was to assess the quality of clinical information included in referrals and therefore assess the justification for the CT examination.

Referrals from 450 diagnostic CT scans undertaken on a single day were retrospectively reviewed by consultant radiologists to assess justification. Each referral was independently assessed by two reviewers. They were asked to assess the justification of each scan based on the clinical information provided in the referral and any relevant previous imaging. The reviewers were asked to base their decision on the information included in iRefer: Making the best use of clinical radiology[2]. For referrals considered to be unjustified, the reviewers were asked to state whether a different modality would have been appropriate. Where consensus was not reached between the initial two reviewers, arbitration was provided by a separate pair of consultant radiologists who reviewed the referrals together.

This study found that 94% of the CT referrals reviewed were justified. The number of justified scans varied with regard to the anatomical region being scanned, with the abdomen and pelvis being the only region that demonstrated any statistical significance in the number of unjustified examinations.

This review shows that, at a time when increasing emphasis is being placed on the use of embedded clinical decision support software, conventional systems utilising up-to-date referral criteria and robust justification processes can ensure that inappropriate examinations are rare.

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[1] The Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2000 (SR 2000 No. 194). Belfast: HMSO
[2] The Royal College of Radiologists. iRefer: Making the best use of clinical radiology. London: The Royal College of Radiologists 2012 http://www.irefer.org.uk/

Introduction

The Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2000[1] (IR(ME)R) implement the European Council Medical Exposures Directive 1997[2] and are designed to ensure that individuals undergoing medical exposures are protected from the associated risks of ionising radiation. The responsibility for assessing compliance with and enforcing IR(ME)R transferred from the Department of Health, Social Services and Public Safety to the Regulation and Quality Improvement Authority (RQIA) on 15 March 2010 under The Ionising Radiation (Medical Exposure) (Amendment) Regulations (Northern Ireland) 2010. RQIA is the independent health and social care regulatory body for Northern Ireland. RQIA encourages continuous improvement in the quality of services, through a planned programme of inspections and reviews.

Since completing work on this survey, new Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2018[3] have come into force, however the justification requirements remain unchanged.

Under IR(ME)R, no medical exposure may be performed unless it has been justified and authorised. Justification is the process of ensuring the expected benefits for a patient of a medical exposure are greater than the potential detriment of the associated radiation dose. Justification is one of the key principles of radiological protection, alongside optimisation and dose limitation, as described by the International Commission on Radiological Protection[4] (ICRP). Authorisation is the means by which it can be demonstrated that justification has taken place.

The responsibility for enforcement of IR(ME)R in Northern Ireland lies with RQIA. As part of its programme of assessing compliance with IR(ME)R, RQIA asked Public Health England (PHE) to undertake a retrospective review of the justification of computed tomography (CT) examinations in Northern Ireland.

The scope of this review did not include an assessment of the clinical outcome for the patient.

Northern Ireland has a population of approximately 1.85 million people[5]. During 2014/15 there were 606,144 inpatient and day case admissions to hospital[6] and 590,000 attendances at Emergency Departments[7]. It has five Health and Social Care Trusts (excluding the Northern Ireland Ambulance Service Trust) and the majority of hospitals use the same Picture Archiving and Communication System (PACS). The hospitals not linked to the regional PACS have easy access to the system. This means that all radiology departments are able to check previous imaging history for their patients. At the time of the study, there were 25 CT scanners installed in Northern Ireland.

Referrals for CT examinations are made via a number of different pathways. Electronic referral systems are widely available to referrers based in hospital settings however paper referrals are also used.

Methodology

The review of the justification of CT examinations was undertaken on the basis of assessing all examinations undertaken on a single day. All referrals for diagnostic CT scans undertaken on Tuesday 13th January 2015 were included retrospectively in the review. This date was selected as it avoided any routine equipment service downtime and the increased workload typically seen immediately before and after a weekend.

Some scan types were excluded from the study. Radiotherapy planning scans were excluded as the basis for justification is inherently different to those undertaken for diagnostic purposes. Diagnostic CT scans undertaken in the independent sector were excluded due to difficulties associated with accessing referral information. The purpose of CT within a hybrid examination can be for attenuation correction, localisation or diagnosis, which may be different from stand-alone CT examinations. For this reason hybrid imaging examinations were also excluded from the review.

The Royal College of Radiologists (RCR) provided a group of 13 experienced consultant radiologists to act as reviewers.

Referrals were anonymised to ensure patient confidentiality but included the age, gender, clinical history and examination requested. Data relating to the time the scan was performed were also available. Reviewers had access to a summary of previous imaging history for each patient.

Each referral was independently assessed by two reviewers. They were asked to assess the justification of each referral based on the clinical information provided and any relevant previous imaging. The reviewers were asked to base their decision on the information included in iRefer: Making the best use of clinical radiology[8].

The reviewers recorded the justification status of each scan on a spreadsheet. The following options were available to them:
- Justified
- Unjustified
- Unsure

For scans considered to be unjustified, the reviewers were then asked to state whether they considered that a different modality would have been appropriate. The options available were:

- No
- Yes, ultrasound
- Yes, MRI
- Yes, plain film
- Yes, nuclear medicine
- Yes, fluoroscopy

A free text box was available for the reviewers to include any additional comments relevant to their assessment, for example, "Given age and apparent lack of urgency, MRI is preferable". Appendix 1 includes a full list of comments for those referrals that were considered to be unjustified.

This free text box was also used by some reviewers to explain their decision on whether the scan was justified, for example, "Previous history of Hodgkin's disease 2013". Any additional comments were reviewed independently by two experienced CT radiographers and where these raised questions about appropriate protocol selection e.g. where more or less than the anatomical area requested was scanned, the referrals were sent for arbitration.

For each CT scan, the results of the independent assessment were compared. Where consensus was not reached between the initial two reviewers, or where both reviewers were unsure of the justification, an independent pair of consultant radiologists provided arbitration. These reviewers worked together to discuss each referral and reach a decision on justification. These arbitrating radiologists had access to the same information as the original reviewers but did not have access to the results of the initial review. They were asked to record whether the scan was justified or unjustified and were not given an 'unsure' option. If the referral was unjustified, the two arbitration radiologists were asked to record whether another modality would have been appropriate.

Following arbitration, the number of justified and unjustified referrals was compared. The referrals were grouped by patient gender, patient age, geographical location and anatomical region scanned, and compared using the two-sided Fisher exact tests. All analyses were performed using the R-Project Software[9] and p-values of less than 0.05 were considered statistically significant.

Further retrospective analysis of the data contained within the referrals was carried out to assess the quality of information provided to the practitioner. This included an assessment of:

- Electronic and hand-written referrals
- Pregnancy status
- Time of scan

Where referrals were identified as unjustified, further analysis was performed on the referral source and patient location.

Results

A total of 586 unique referrals from examinations carried out on the 13th January 2015 were sent to PHE for data analysis. 136 referrals had to be removed from the initial review as they were not reviewed independently. 450 referrals were reviewed independently by 13 radiologists from the Royal Devon and Exeter NHS Trust (RD&E).

Following the initial independent review, the responses from both reviewers were compared. The results of the review of justification of the CT scans by the initial reviewers are given in Table 1

Table 1: Results of the initial independent review

Initial review status	Numbers of referrals
Reviewers agree - Justified	354*
Reviewers agree - Unjustified	12
Reviewers agree - Unsure	1
Reviewers disagree	83
Total	450

*Of these 354 referrals, 32 were deemed to be justified by both reviewers but at least one of the reviewers included additional comments. A review of these additional comments by two experienced CT radiographers working within PHE highlighted questions about appropriate protocol selection. As a result of this separate review, 3 of these referrals were deemed to require further arbitration.

Arbitration of those referrals where the initial reviewers disagreed, agreed as unsure, or where additional comments were made about protocol selection, was carried out by two experienced radiologists. These individuals were not involved in the initial review. The referrals that were selected for arbitration included those where the reviewers disagreed (83), those where both reviewers were unsure (1) and those identified in the review by PHE (3). A total of 87 referrals were sent for arbitration and these were reviewed jointly with reference to iRefer and without access to the initial review results.

Following arbitration, 15 referrals were deemed unjustified and 72 justified. Table 2 shows the final justification status of all 450 referrals once arbitration decisions were taken into account.

Table 2: Overall justification of scans following arbitration

	Justified				Unjustified			
	Initial Review		Post Arbitration		Initial Review		Post Arbitration	
Number of referrals	351	78%	72	16%	12	3%	15	3%
Total number of referrals	423 (94%)				27(6%)			

In total, 423 scans were considered to be justified or 94% of the referrals assessed in this study.

Justification According to Gender of Patients

Over the 24 hour period of the review, 233 scans were performed on female patients and 217 scans were performed on male patients. Of the 27 unjustified referrals, 17 were undertaken on female patients and the remaining 10 were on male patients. Table 3 shows the unjustified scans as a function of gender.

Table 3: All referrals based on gender

	Justified		Unjustified		Total	p-value
Male	207	95%	10	5%	217	0.24
Female	216	93%	17	7%	233	0.24
Total	423	94%	27	6%	450	

Analysis of the data found no statistically significant difference between male and female patients.

Justification According to Age and Gender of Patients

The age range of all subjects included in this review was 2-110 with an average age of 60. Figure 1 shows the population distribution and the numbers of justified and unjustified referrals within 10-year age ranges for male and female patients.
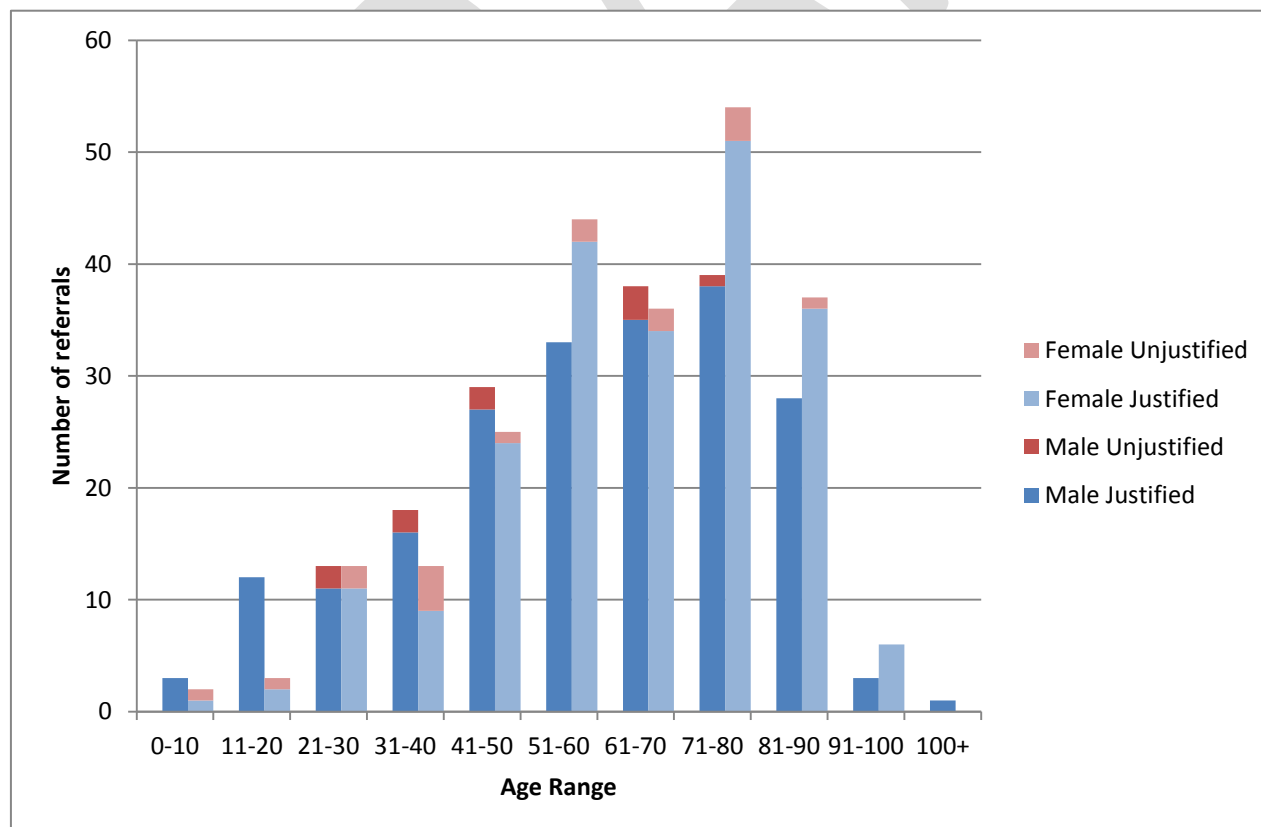

Figure 1: All referrals by age and gender

The justification rate of grouped male and female data in each age bracket was compared to the overall justification rate. The data showed a statistical significance for the age range 31-40 where 19% (6/31) of referrals were unjustified (p=0.007).

This data was analysed further against patient gender and while the justification rate for male patients aged 31-40 was not significantly different to the overall rate (p=0.196), the justification rate for female patients within this age range was significantly different (p=0.009).

Justification by Geographical Distribution

Table 4 shows the distribution of examinations across the five Trusts included within this review. Four of the Trusts showed similar numbers of unjustified referrals. Trust C showed the highest percentage of unjustified referrals.

Table 4: All referrals by geographical distribution

	Justified referrals		Unjustified referrals		Total	p-value
Trust A	69	97%	2	3%	71	0.284
Trust B	79	95%	4	5%	83	0.800
Trust C	78	89%	10	11%	88	0.025
Trust D	74	96%	3	4%	77	0.597
Trust E	123	94%	8	6%	131	1.000
Total	423	94%	27	6%	450	

11% of all referrals within Trust C in this study were unjustified. The rate of unjustified referrals for this Trust was significantly higher when compared to the other Trusts (p=0.025).

Justification by Anatomical Grouping

There were 53 different examination descriptors used in this study. In order to simplify analysis, these were arranged into nine separate groupings (see Appendix 2). The number of justified referrals varied with regard to the anatomical grouping being scanned.
Table 5 shows the type and number of examinations included in this study. The rate of unjustified referrals for the abdomen/pelvis region was significantly higher than the overall rate with 12% (8/64) of referrals considered unjustified (p=0.040).

Table 5: The number of referrals according to anatomical grouping

Anatomical group	Justified referrals		Unjustified referrals		Total	p-value
Abdo/Pelvis	56	88%	8	12%	64	0.040
Angio	28	97%	1	3%	29	1.000
Chest	52	96%	2	4%	54	0.758
CTC	20	95%	1	5%	21	1.000
Extremity/Ortho.	16	94%	1	6%	17	1.000
Head	168	94%	10	6%	178	0.842
Interventional CT	2	100%	0	0%	2	1.000
NCAP/CAP	57	95%	3	5%	60	1.000
Urinary Tract	24	96%	1	4%	25	1.000
Total	423	94%	27	6%	450	

Alternative Diagnostic Modalities

For scans considered to be unjustified, the initial reviewers and arbitration reviewers were asked to state whether they considered that a different modality would have been appropriate.

Of the 27 unjustified referrals, the reviewers felt that 15 of these cases could have had an alternative modality. These results are shown in Table 6.

Table 6: Suggested alternative modalities for unjustified referrals

Appropriate alternative modality	Number of referrals	Percentage of referrals
No	12	44%
Ultrasound	3	11%
MRI	9	33%
Plain Film	2	7%
Nuclear Medicine	0	0%
Fluoroscopy	0	0%
Free text (endoscopy)	1	4%

For one referral, the reviewers indicated within the free text box that endoscopy would have been a better alternative modality.

The highest alternative modality was MRI at 33% (9/27) and this was predominantly for CT Head referrals. As shown in Table 5, there were a total of ten unjustified CT Head referrals and of these, the reviewers considered that MRI would have been more appropriate in eight cases.

All three referrals where ultrasound was suggested as an alternative modality were for abdomen/pelvis scans.

Figure 2 shows the number of unjustified referrals by anatomical grouping and the identified alternative modality considered more appropriate.
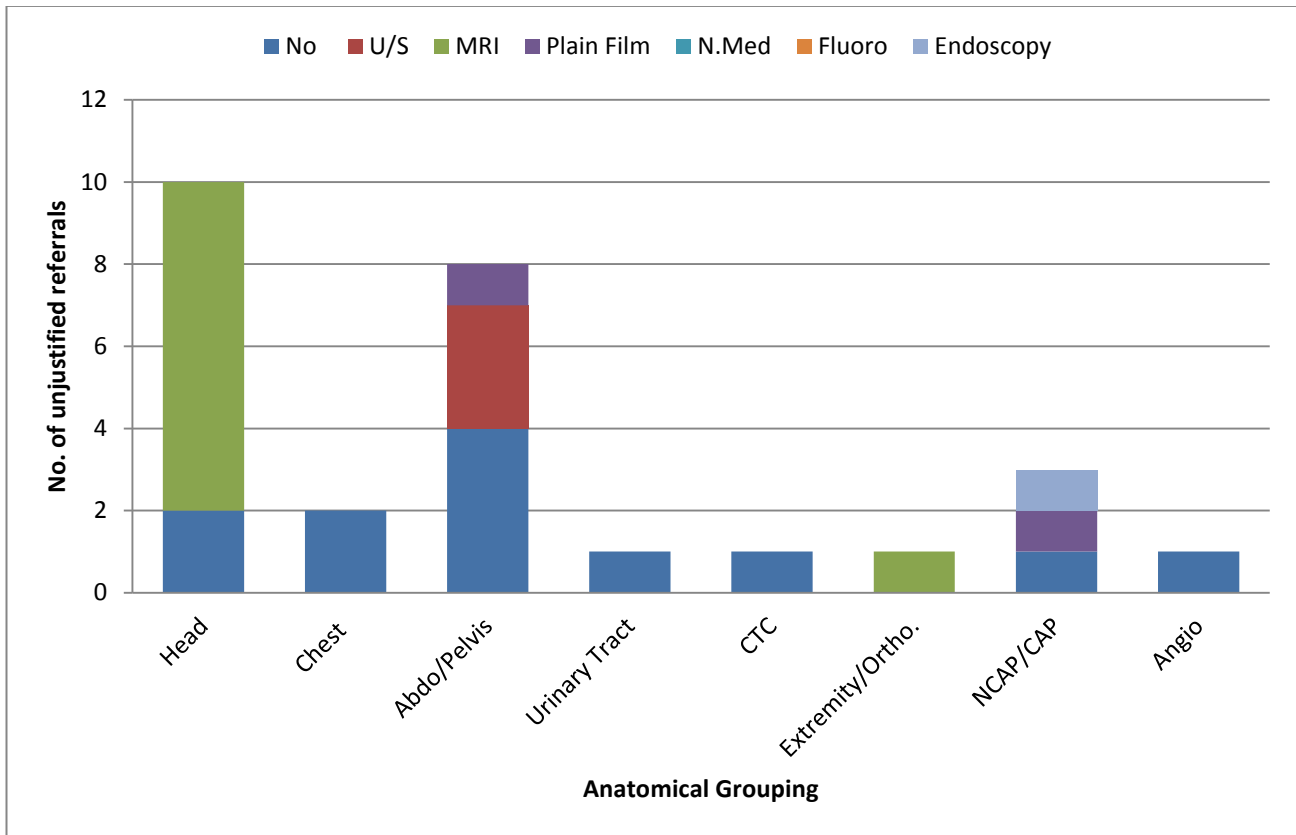

Figure 2: All unjustified referrals against alternative modality

12 unjustified referrals did not have alternative modality indicated or a "no" answer was given to this question.

In two of these 12 unjustified cases, the reviewers had indicated that additional body regions were scanned when the reviewer deemed this to be unnecessary. An example of this is a Chest Abdomen Pelvis (CAP) was requested but only the Abdomen and Pelvis were justified in accordance with the information supplied on the referral.

The reviewers described the clinical information on seven of these 12 cases as being unclear/inadequate or did not comply with iRefer. The reviewers also noted on some occasions that verbal conversations may have taken place between the referring clinician and the practitioner but that this was not recorded on the referral

Five of these 12 referrals were considered unjustified when the age of the patient was taken into consideration.

Justification According to Referral Source

All unjustified referrals were analysed to determine the referral source. Figure 3 shows number of overall referrals with the number of unjustified referrals within each referral source where unjustified referrals were present. Table 7 shows the remaining referral sources where no unjustified referrals were considered to be present.
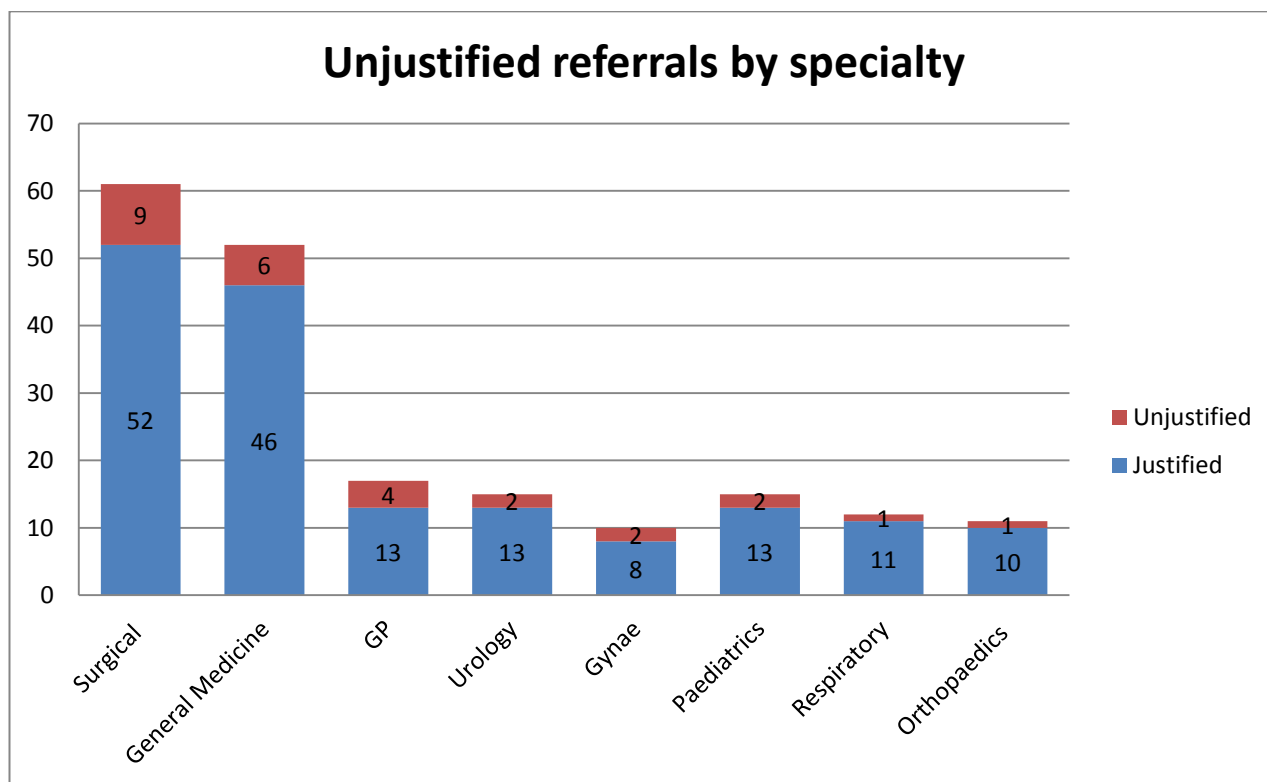

Figure 3: All referrals against referring speciality

Of the 27 unjustified referrals, there were 15 out-patients, eight in-patients and four GP referrals.

The referrals in this study were 73% electronic and 27% hand written.

Table 7: Number of referrals according to speciality without any unjustified referral

Speciality	Number of referrals
ITU/HDU	4
Care of the Elderly	4
Haematology	6
Psychiatry	5
ENT	14
Gastroenterology	21
Cardiac	20
Oncology	27
Neurology	43
Accident and Emergency	114

Figure 4 shows the results of unjustified referrals against all speciality groups according to anatomical grouping.
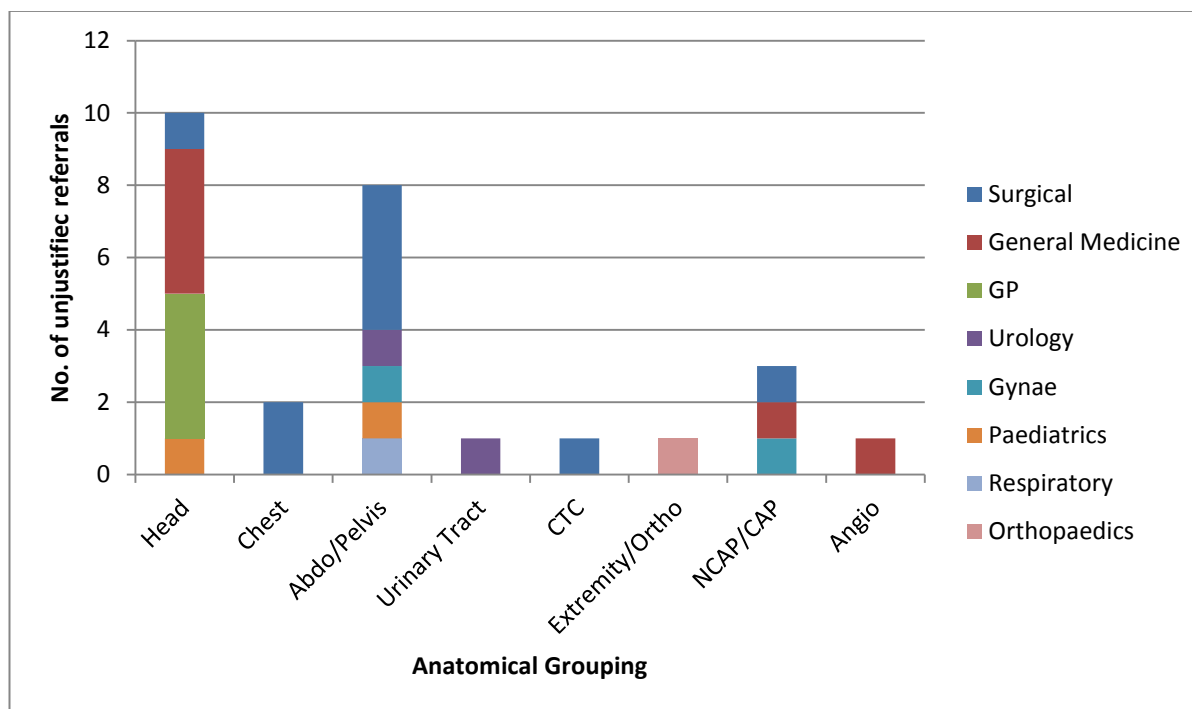

Figure 4: Anatomical grouping of unjustified referrals against referring speciality

Justification According to Time of Scan

Data was available relating to the time each scan was performed, 25 of the 27 unjustified scans were performed within the hours of 9:00 – 17:00. The two remaining unjustified scans were performed at 17:03 and 18:40. Over the 24 hour period 83% of examinations were performed between 9:00 and 17:00.

Assessment of Pregnancy Enquiries

From the information available on the referral forms, the results showed that 67 female patients were within the age range of 12-55 years. This range is normally used to determine those patients of child bearing potential and where further questions may be asked regarding pregnancy status. Of these 67 patients, 44 had an examination that involved irradiation of the area between the diaphragm and knees.

Of these 44 female patients it was found that six patients had been incorrectly identified on the referral form by the referrer as being outside the age range for checking pregnancy status, these patients ranged from 27-54 years of age. A further seven patients within the eligibility criteria lacked any information on pregnancy status on the referral.

Discussion

CT is a powerful and highly flexible clinical tool capable of making radical changes to the management of patients. The most appropriate use of CT relies on many factors which must be considered each and every time a scan is justified. In some cases the outcome of that consideration may be that the CT scan is not performed and an alternative examination that does not involve the use of ionising radiation is used to answer the clinical question.

The aim of this study was to assess the justification of CT referrals carried out within a 24 hour period across five Trusts in Northern Ireland. The process of justification according to IR(ME)R is weighing up the expected net benefit of the exposure against the possible detriment of the associated radiation dose. The study retrospectively assessed the clinical information provided on CT referrals taking into account any relevant previous imaging. The scope of this study did not include the patient's clinical outcomes. It is also important to note that verbal discussions that occurred between the referrer and practitioner, which may have informed the justification process, were not recorded and were therefore outside the scope of this study.

The Royal College of Radiologists provided a group of 13 experienced consultant radiologists to act as reviewers. The reviewers were asked to independently analyse the clinical information provided on the referrals and state if the examination was justified, un-justified or unsure. Arbitration was used in cases where consensus could not be reached.

When compared to a study[10] in Sweden from 2009 which found that 80% of all examinations were justified, the results from Northern Ireland show a more favourable result with 94% of all CT referrals justified. Both studies found the degree of justification varied depending on the organ being examined.

Some variation was found when analysing the unjustified referrals according to geographical location. Trust C had the highest percentage of unjustified referrals with 11% compared to Trust A where the percentage of unjustified referrals was 3%. Trust C also had the highest number of unjustified scans (five) where MRI would have been a more appropriate imaging modality. It is not possible to determine a reason for this variation from the data reviewed.

As part of the justification process, consideration of the use of alternative techniques having the same objective but involving no or less exposure to ionising radiation must be considered. The reviewers were asked to indicate if an alternative modality would have been more appropriate in the referrals that were deemed unjustified. A total of 15 of the 27 referrals were identified as such. In 48% of the unjustified referrals a non-

ionising radiation technique was suggested. MRI was suggested in 33% of unjustified referrals as a more appropriate modality. Eight of these referrals were CT Head scans with 50% of these CT Head referrals requested by General Practitioners, 24% of all referrals from this speciality group were deemed unjustified. It is not stated within the scope of this study if MRI was available in the hospital at the time of the CT scan being performed. It is understood that the choice of imaging procedure will be influenced by the availability of a particular test within a suitable timeframe for the clinical condition of each patient.

Where ultrasound was indicated as an alternative examination, all cases in this data set were from the abdomen/ pelvis group which was the only anatomical grouping to show a statistically significant difference. This result is important given the abdomen and pelvis region contains organs with a higher radiosensitivity factor (ICRP[4]) and CT scans of this region tend to be considered as high dose procedures.

A free text box allowed the reviewers to make additional comments and in two referrals the reviewers felt that additional scanning was carried out which was not justified based on the clinical information on the referral. Seven referrals were deemed to lack adequate clinical information in accordance to iRefer.

The age range of the patients in this study spanned from 2-110 years with an average age of 60 years. The predicted risk of developing cancer from exposure to ionising radiation varies from three to five fold depending on the age at which the exposure occurs[11]. IR(ME)R requires special attention to be paid to the medical exposures of children. The justification rate for paediatric patients was not statistically significantly different from the overall justification rate, however the reviewer comments did show that in five cases the referrals were judged as unjustified when the age of the patient was considered against the clinical history.

There are notable advantages to CT over MRI in accessibility, such as fast scan times with a reduction in the need for sedation in children. However it is widely understood that children have a greater radiosensitivity than adults therefore needing specific justification based on their age. Two of the unjustified referrals were on paediatric patients. Notably these involved a two year old child for a CT of the pelvis where the reviewers felt an x-ray would have provided sufficient information and a 15 year old for a CT scan of the head where MRI was suggested as a more appropriate alternative modality.

When the data was analysed to identify the source of the unjustified referrals the study found the highest proportion of unjustified referrals came from General Practitioners (GPs), 24%, followed by the surgical team, 12%, and general medicine, 12%. The four unjustified referrals from GPs were all referrals for CT Head scans and the reviewers felt that based on the clinical information provided, an MRI of the brain would be a more

appropriate modality. These findings may indicate a lapse in the use of referral criteria or indeed a lack of access.

The study found a statistically significant result in the female patients in the age range 31-40. This finding led to further analyses of the referral forms to look at pregnancy information supplied by the referrer. The study included 67 females of child bearing age (12-55). Of these, 44 female patients had a CT scan performed where the primary beam would irradiate between diaphragm and knees. Six of these 44 patients had been incorrectly identified on the referral as being outside the age range for checking pregnancy status. These six patients were aged between 27-54 years old. A further seven patients within the eligibility criteria lacked any information on pregnancy status on the referral form. It is understood that the task of pregnancy checking is the role of the operator. However under IR(ME)R the referrer must supply sufficient medical information to allow the justification process to take place.

Conclusion

The study showed the overall justification rate of CT referrals in this study was 94%. The majority of CT referrals had sufficient clinical information provided by the referrer to justify the examination according to iRefer.

The quantity and complexity of CT imaging continues to increase year on year. Therefore the avoidance of any unnecessary radiation dose, however small, is paramount. The availability of alternative modalities that do not use ionising radiation, such as MRI and ultrasound, will have an influence on the justification rate of CT referrals as we have seen from the data in this study.

Acknowledgements

We would like to take this opportunity to thank Dr John Lawson, Dr Ronan McNally and Dr Giles Maskell (past President of the Royal College of Radiologists) for their advice and support for this review. We are extremely grateful to all of the reviewers for giving up their time; without their input this review would not have been possible.

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Appendix 1: Reasons for unjustified referrals

Should have had initial plain x-ray as appearances bony
MRI or nothing
This is hard to justify on the basis of the given information. It seems likely that the case was discussed with the radiologist (as per advice) and if in an appropriate setting the scan may be reasonable.
There may have been further discussion which is not recorded. Patient is young female with recent ultrasound scan.
No symptoms and marginal findings at best on original scan
Incorrect recommendation by initial reporting radiologist. This would be hard for the vetting person as it was recommended.
Should have other investigations including ultrasound first
Ideally should be MRI
Not indicated by guidelines. If anything MRI
Not indicated as per iRefer
Evidence of discussion with radiologist. Scan was not limited to area of concern in the gallbladder.
MRI if required
Multiple recent CT scans. Consider MRI if scan needed. More information needed.
Endoscopy first
Depending on current clinical symptoms either CT abdo/pelvis or colonoscopy.
Only if know cancer
Chronic headache with no neurology
Reason for request is unclear
Should be able to tell on XR if reduced.
No convincing evidence of stone disease. Needs US first.
Patient is young. Consider US first.
Given age and apparent lack of urgency, MRI is preferable
Will depend on what non-contrast scan shows
Young patient. Should have MRI

Appendix 2: Examination grouping

Head	CT Brain
	CT Petrous Bones
	CT Brain Perfusion Study
	CT Facial Bones
	CT Sinuses
	CT Brain with contrast
	CT Temporal Bones
	CT Head
	CT Head with contrast
Chest	CT Angiogram pulmonary
	CT Chest
	CT Chest high resolution
	CT Chest with contrast
	CT Lung nodule
	CT Neck and Chest
Abdo/Pelvis	CT Abdomen and pelvis
	CT Abdomen and pelvis with contrast
	CT Pelvis
	CT Liver
	CT Liver with contrast
	CT Liver triple phase
	CT Pancreas dual phase
	CT Abdomen with contrast
	CT Abdomen
Urinary Tract	CT Renal Both
	CT Urogram
	CT KUB
	CT Urinary tract
CTC	Enhanced CT Colonography
	CT Colonoscopy virtual
Extremity/Ortho.	CT Wrist Rt
	CT Knee Lt
	CT Knee Rt
	CT Shoulder Rt
	CT Wrist Lt
	CT Ankle Rt
	CT Foot Lt
	CT Foot Rt
	CT Spine Cervical
NCAP/CAP	CT Chest and abdo and pelvis
	CT Chest and abdo and pelvis with contrast
	CT Chest and abdomen
	CT Chest and abdomen with contrast
	CT Neck chest,abdomen and pelvis
Angio	CT Angiogram intracranial
	CT Angiogram lower limb both
	CT Endovascular Aneurysm Surveillance (EVAR STENT)
	CT Cardiac angiogram coronary
	CT Angio aortic arch and carotid both
	CT Cardiac Cor artery calcium scoring
Interventional CT	CT Guided ablation
	CT Guided aspiration