BIROn - Birkbeck Institutional Research Online

Evans, Ruth and Taylor, S. and Beare, S. and Halligan, S. and Morton, A. and Oliver, A. and Rockall, A. and Miles, Anne (2018) Perceived patient burden and acceptability of whole body MRI for staging lung and colorectal cancer; comparison with standard staging investigations. British Journal of Radiology 91 (1086), ISSN 0007-1285.

Full title page

Title of the paper: Perceived patient burden and acceptability of whole body MRI for staging lung and colorectal cancer; comparison with standard staging investigations.

Running head: Patient burden and acceptability of WB-MRI vs. standard scans

Type of manuscript: Full paper

Authors: Ruth EC Evans (PhD) [a], Stuart A Taylor (MD) [b], Sandra Beare (PhD) [c], Steve Halligan (PhD),[b] Alison Morton,[d] Alf Oliver (LL.B Hons),[d] Andrea Rockall (MD),[e f] Anne Miles (PhD),[a] on behalf of the Streamline Investigators.[g]

[a] Psychological Sciences, Birkbeck, University of London, Malet Street, London, WC1E 7HX. ruthecevans@gmail.com and ae.miles@bbk.ac.uk

[b] Centre for Medical Imaging, Division of Medicine, University College London, Gower Street, London, WC1E 6BT: *stuart.taylor@uclh.nhs.uk* and s.halligan@ucl.ac.uk

[c] CR UK &UCL Clinical Trials Centre, 90 Tottenham Court Road, London, W1T 4TJ: s.beare@ucl.ac.uk

[d] c/o National Cancer Research Institute, Angel Building, 407 St John Street, London, EC1V 4AD : alisonmorton41@gmail.com and olivera@olivera.karoo.co.uk

[e] Department of Surgery and Cancer, Imperial College London, Kensington, London SW7 2AZ : a.rockall@imperial.ac.uk

[f] Department of Radiology, Royal Marsden NHS Foundation Hospital Trust, Fulham Road, London, SW3 6JJ

[g] Streamline Investigators listed in the collaborators section

Collaborators:

The authors of this paper are part of a wider group that form the Streamline trials investigators and include the following collaborators: A Aboagye, L Agoramoorthy, S Ahmed, A Amadi, G Anand, G Atkin, A Austria, S Ball, F Bazari, R Beable, H Beedham, T Beeston, N Bharwani, G Bhatnagar, A Bhowmik, L Blakeway, D Blunt, P Boavida, D Boisfer, D Breen, J Bridgewater, S Burke, R Butawan, Y Campbell, E Chang, D Chao, S Chukundah, B Collins, C Collins, V Conteh, J Couture, J Crosbie, H Curtis, A Daniel, L Davis, K Desai, M Duggan, S Ellis, C Elton, A Engledow, C Everitt, S Ferdous, A Frow, M Furneaux, N Gibbons, R Glynne-Jones, A Gogbashian, V Goh, S Gourtsoyianni, A Green, Laura Green, Liz Green, A Groves, A Guthrie, E Hadley, A Hameeduddin, G Hanid, S Hans, B Hans, A Higginson, L Honeyfield, H Hughes, J Hughes, L Hurl, E Isaac, M Jackson, A Jalloh, S Janes, R Jannapureddy, A Jayme, A Johnson, E Johnson, P Julka, J Kalasthry, E

Karapanagiotou, S Karp, C Kay, J Kellaway, S Khan, D Koh, T Light, P Limbu, S Lock, I Locke, T Loke, A Lowe, N Lucas, S Maheswaran, S Mallett, E Marwood, J McGowan, F Mckirdy, T Mills-Baldock, T Moon, V Morgan, S Morris, S Nasseri, N Navani, P Nichols, C Norman, E Ntala, A Nunes, A Obichere, J O'Donohue, I Olaleye, A Onajobi, T O'Shaughnessy, A Padhani, H Pardoe, W Partridge, U Patel, K Perry, W Piga, D Prezzi, K Prior, S Punwani, J Pyers, H Rafiee, F Rahman, I Rajanpandian, S Ramesh, S Raouf, K Reczko, A Reinhardt, D Robinson, P Russell, K Sargus, E Scurr, K Shahabuddin, A Sharp, B Shepherd, K Shiu, H Sidhu, I Simcock, C Simeon, A Smith, D Smith, D Snell, J Spence, R Srirajaskanthan, V Stachini, S Stegner, J Stirling, N Strickland, K Tarver, J Teague, M Thaha, M Train, S Tulmuntaha, N Tunariu, K van Ree, A Verjee, C Wanstall, S Weir, S Wijeyekoon, J Wilson, S Wilson, T Win, L Woodrow, D Yu.

Abstract

Objectives – To evaluate perceived patient burden and acceptability of whole body MRI (WB-MRI) compared to standard staging investigations, and identify predictors of reduced tolerance.

Methods – Patients recruited to multi-centre trials comparing WB-MRI with standard staging scans for lung and colorectal cancer were invited to complete two questionnaires: a baseline questionnaire at recruitment, measuring demographics, comorbidities, and distress; and a follow-up questionnaire after staging, measuring recovery time, comparative acceptability/ satisfaction between WB-MRI and CT (colorectal cancer) and PET-CT (lung cancer), and perceived scan burden (scored 1 low to 7 high).

Results – 115 patients (median age 66.3 years; 67 males) completed follow-up and 103 baseline questionnaires. Sixty-nine (63.9%) reported "immediate" recovery from WB-MRI and 73 (65.2%) judged it "very acceptable". Perceived WB-MRI burden was greater than for CT ($p<0.001$) and PET-CT ($p<0.001$). High distress and co-morbidities were associated with greater WB-MRI burden in adjusted analyses, with deprivation only approaching significance (adjusted regression Beta=0.223, $p=0.025$; Beta=0.191, $p=0.048$; Beta = -0.186, $p=0.059$ respectively). Age ($p=0.535$), gender ($p=0.389$), ethnicity ($p=0.081$) and cancer type ($p=0.201$) were not predictive of WB-MRI burden.

Conclusions: WB-MRI is marginally less acceptable and more burdensome than standard scans, particularly for patients with pre-existing distress and comorbidities.

Advances in knowledge: This research shows that WB-MRI scan burden, although low, is higher than for current staging modalities among patients with suspected colorectal or lung cancer. Psychological and physical co-morbidities, adversely impact on patient experience of

WB-MRI. Patients with high distress or comorbid illness may need additional support to undergo a WB-MRI.

Introduction

Patients diagnosed with cancer must be staged accurately prior to treatment decisions. In particular it is imperative to detect metastatic disease, as this impacts considerably on therapeutic approach. Standard staging pathways are often complex, time consuming and involve several different imaging modalities, potentially adding to physical and psychological burden of patients with known or suspected cancer.[1]

Recent data suggests whole body MRI (WB-MRI) has potential as an "all-in-one" staging investigation that at least matches and possibly betters the accuracy of conventional investigations for detecting metastatic disease.[2;3] One critical but often neglected aspect influencing adoption of any new technology is patient experience. Low patient acceptability reduces adherence, which diminishes diagnostic impact, even when superior to existing tests. Uptake of bowel cancer screening colonoscopy is an example where perceived test burden impacts directly to reduce participation.[4]

WB-MRI has several attributes that can impact negatively on patient experience. Although protocols are dependent upon the underlying disease process, the scan acquisition time for cancer staging is typically around 45 to 60 minutes, and considerably longer than CT or even PET-CT, with image acquisitions taking seconds or minutes respectively (although patient experience will be influenced by the total examination time, rather than just time taken for image acquisition). Moreover, MRI scanners are noisy and require full body and head immersion inside a relatively narrow "tube", often necessitating closely applied receiver coils that restrict movement. Existing data show that 5 to 30% of patients experience distress both in anticipation of MRI, and during the scan itself.[5-7] Severe claustrophobia terminates scanning in 1 to 15%,[8] and even if the patient completes the scan, distress precipitates motion

artefacts that degrade image quality and impair diagnostic accuracy.[9] Furthermore, post scan anxiety[6] can engender MRI fear or phobia.[10]

Quantifying patient "distress" around diagnostic imaging is complex and has been expressed as procedural "burden", a composite variable based on rating the level of physical and psychological discomfort related to scanning. Shortman et al.[11] found the perceived burden of PET-MRI was greater than PET-CT; burden was related to scan preference with an over-all preference for PET-CT. A recent qualitative interview study reported that WB-MRI was perceived by some as more challenging than PET-CT and CT.[12] To date, predictors of increased patient burden before or during WB-MRI have received little attention. Such knowledge may identify those who require additional psychological support in advance or physical interventions such as sedation in order to complete scanning.[13]

The purpose of this study was to evaluate the perceived patient burden and acceptability of whole body MRI compared to standard staging investigations, and to identify predictors for reduced patient tolerance.

Methods and materials

Participants

Patients recruited prospectively to two ongoing clinical trials, comparing the diagnostic accuracy and cost-effectiveness of WB-MRI with standard tests for staging colorectal and lung cancer, were invited to participate in the current study. Patients were eligible for the main trials if they were recently diagnosed or highly suspected of colorectal (Streamline C) or non-small cell lung cancer (Streamline L), such that they were referred for staging investigations. Written consent was obtained for participation in the current study. As part of the trial protocol, patients underwent WB-MRI staging in addition to all standard staging investigations such as CT and PET-CT. The full trial protocol details have been previously

reported.[14] The WB-MRI required intravenous cannulation for the administration of gadolinium. Full ethical permission was given by Camden and Islington National Research Ethics Service (NRES) on 03/10/2012, project numbers: 12/LO/1176 (Streamline C) and 12/LO/1177 (Streamline L).

Between March 2013 and July 2015, 392 consecutive patients recruited to the main trials were given the option to participate in either an interview study (reported elsewhere[12]) or the current questionnaire study as part of the informed consent process for the main trials. Three hundred and fifty (89.3%) consented. The interview study investigated patients' experiences of staging investigations.

Initially, patients (n=91) were recruited to the interview study, previously reported.[12] Thereafter patients were recruited exclusively to the questionnaire study presented here. None of the patients who took part in the present study took part in the prior interview study. The full recruitment pathway and reasons for exclusion is presented in Figure 1. A total of 115 patients completing the follow up questionnaires (see below) were included in the analyses.

Procedures

Patients were asked to complete two questionnaires. The first (baseline) questionnaire was mailed to patients within 2 days of being registered for the Streamline trials, completed around the time patients were undergoing their staging investigations, and returned using a stamped addressed reply envelope. A second "post staging" questionnaire was posted one month after the baseline questionnaire was administered and was completed after all staging investigations were completed. Patients were paid £20 for participation, which was continued until a minimum of 100 patients had returned both questionnaires (50 for Streamline L and 50 for Streamline C)-see power calculation below.

Questionnaire content

The following data were collected in the baseline questionnaire:

(i) Emotional Distress: The 12 item General Health Questionnaire (GHQ-12)[15] was used to assess psychological distress. An example item is, *"In the last three months have you....been able to concentrate on whatever you're doing"*. Using the GHQ-12 binary coding method (0,0,1,1), a mean sum score (if at least 50% of items were answered) was created ranging from 0 to 12. A score of 4 or higher is considered indicative of significant distress levels.[16]

(ii) Co-morbidity: Patients were asked about their current and recent physical health and mental well-being. Patients were asked to report ("yes" or "no") whether they had any of the following diseases: heart or vascular disease, diabetes, epilepsy, stroke, arthritis, asthma, mental or emotional disorder. There was also an option to provide details of other illness. A response of "yes" to any illness was coded and a dichotomous "co-morbidity" variable was created whereby the presence of one or more comorbid illness was reported: either yes or no. The presence of a mental or emotional disorder was excluded as this was captured in the GHQ-12. Self-report measures of comorbidity have been shown to be valid[17;18] and offer a more cost-effective method of data collection than medical record-based measures.

(iii) Demographics: Patients were asked their age, gender and ethnicity. Missing demographic data on age and gender as well as zip code data were supplied via the central trial database (with patient consent). Zip code data were used to calculate an area based deprivation score for each individual using the 2010 IMD scale,[19] categorised into quintiles from 1 (highest levels of deprivation) to 5 (lowest).

Part of the follow up questionnaire asked patients about their comparative experience of WB-MRI and staging CT chest, abdomen and pelvis (standard scan) if recruited to Streamline C, or to PET-CT (standard scan) if recruited to Streamline L. The following data were captured.

(i)   Scan recovery, satisfaction and acceptability: Patients rated their post scan recovery on a 9-point scale ranging from "immediate" to "a week". Data were collapsed into 3 categories "immediate", "up to 30 minutes" and "over 30 minutes" for analysis. Patients also rated how satisfied they were with the information received before scanning, communication and departmental facilities, as well as the overall acceptability of scans, on a scale of 1(very dissatisfied/ not at all acceptable) to 4 (very satisfied/ very acceptable).

(ii)   Scan burden was quantified using a questionnaire adapted from one previously used to assess acceptability of colonoscopy[20;21] (Appendix A). Patients completed the 26 item scale for both WB-MRI and standard scans, describing their experiences by ticking agreement on a 1-7 Likert scale where 1 and 7 were anchored to bi-polar statements related to scan discomfort (13 items), worry (6 items), and satisfaction (7 items). An example discomfort item was 1="not claustrophobic" to 7= "claustrophobic". Sub scores for discomfort, worry and satisfaction scales were computed from the mean of completed items (if less than 50% of items were completed, the response was coded as missing). A total score "scan burden" was computed by taking the mean of discomfort, worry and reverse scored satisfaction sub-scales with higher scores equating to greater scan burden.

Power calculation

Power (G*Power - version 3[22]) was based on rejecting the null hypothesis that there was no significant difference in perceived burden of WB-MRI when compared to standard staging

(related t-test). Assuming a medium effect size (d=0.5), alpha of 0.05 and 95% power,[23] a minimum number of 90 patients were required across the two study cohorts (45 in Streamline C and 45 in Streamline L). An effect size of 0.5 is considered the minimal important difference (MID) in quality of life measures,[24] where MID is defined as the smallest difference that patients view as important (beneficial or harmful), and would result in a doctor considering a change in the patient's management.[25]

Statistical Analysis

Analysis was performed using SPSS version 22. Differences in demographic and psychological characteristics between Streamline L and Streamline C cohorts were assessed using the Mann Whitney U test, and Chi Square or Fisher's Exact tests (if 20% or more of the cells in the contingency table had expected counts of less than 5) as appropriate. Related samples Wilcoxon sign tests were used to assess differences between WB-MRI vs CT/ PET-CT in terms of scan recovery time, scan acceptability, and satisfaction with scan-related information, facilities, communication and scan burden. Linear regression tested the predictive value for WB-MRI scan burden of data collected in the baseline questionnaire. Individual predictors were entered in unadjusted analyses and those items achieving statistical significance were then entered into a multivariate analysis. Statistical significance was assigned at the 5% level, two-tailed.

Results:

Of the 350 patients agreeing to participate in the questionnaire or separate interview study, rates of consent were significantly higher among patients recruited to Streamline L compared to those recruited to Streamline C; (93.1% vs. 85.8%; X^2=5.451, df=1; p=0.020), see Figure

1. There were no differences in basic demographics between those who consented compared to those who did not (see Appendix B).

 In total, 214 patients were sent both questionnaires of whom 99 were excluded leaving 115 for analysis. Reasons for exclusion were non response (n=71), returned baseline questionnaire only (n=27), and trial withdrawal (n=1) (Figure 1). Patients with lower levels of deprivation were more likely to return the post staging questionnaire (linear chi-square:7.113, df=1; p=0.008). There were no differences in sex (p=0.059), age (p=0.676) or cancer type (Chi-square=0.442; df=1; p=0.506), between those who did, and did not return the post staging questionnaire (see Appendix C).

Full demographics of the 115 patients are shown in Table 1. Overall, 103 patients (median age 66; 58 males) completed both questionnaires and 12 (median age 60; 9 males) completed the post staging questionnaire only. Sixty one patients were recruited to Streamline C and 54 to Streamline L. Female patients recruited to Streamline C (n=24) were significantly younger than those recruited to Streamline L (n= 24) (median age 60 vs 73 years; p=0.003), with no significant age difference between males (66 years, n=37 vs 66 years, n=30, respectively; p=0.480).

Patients recruited to Streamline L were significantly more likely to report additional comorbidity than those recruited to Streamline C (66.7% vs. 40.4%, p=0.008) with no significant differences for the presence of baseline psychological distress between the two trial cohorts (see Table 1).

Post-scan patient recovery and scan acceptability

Patients' responses to scan recovery time and overall acceptability are summarised in Table 2. There were no significant differences in recovery time after WB-MRI compared to CT/ PET-CT, with 63.9% of patients who completed this item (n=69) reporting "immediate" recovery following WB-MRI compared with 65.1% following CT/PET-CT (see Table 2). However scan acceptability ratings were significantly lower for WB-MRI compared to both CT and PET-CT. Patients' satisfaction with information before the scan and facilities, together with communication during the scan and were all high and not significantly different between WB-MRI and either CT or PET-CT (Table 2).

Scan burden

In general patients tolerated all the imaging modalities well and reported low levels of scan burden. Mean ratings for scan discomfort and worry ranged from 1.63 to 2.65 where 7 represents maximum discomfort or worry. Mean satisfaction scores ranged from 6.25 to 6.53 where 7 represents maximum satisfaction.

However mean burden scores for WB-MRI were significantly greater than those of PET-CT and CT (see Table 3). The higher burden of WB-MRI was mainly due to items related to "discomfort", although there were also significant differences in relation to "satisfaction". Questionnaire items related to "worry" were only less favourable for WB-MRI in comparison to CT, and did not differ for WB-MRI in comparison to PET-CT. Specific items within the discomfort sub-scale particularly relevant to WB-MRI , showed WB-MRI conferred significantly greater feelings of claustrophobia than both CT (means scores 2.81 vs. 1.51; $p<0.001$) and PET-CT (mean scores 3.04 vs 1.98; $p<0.001$); greater burden from scan-related noise compared with both CT (means 2.84 vs. 1.73; $p<0.001$) and PET-CT (2.85 vs. 1.63; $p<0.001$). In general, the intravenous injections required for each of the three scan types

resulted in low levels of discomfort which did not differ between scan type (WB-MR vs CT: 1.59 vs 1.56, p=0.637; WB-MRI vs PET-CT: 1.86 vs 1.73, p=0.225).

WB-MRI burden was not rated differently between those recruited to Streamline C or Streamline L cohorts (see below). In contrast patients recruited to Streamline L reported significantly more worry and discomfort during PET-CT compared to the equivalent ratings for CT by those recruited to Streamline C; (worry 2.52 vs 2.00; p<0.001; discomfort 2.04 vs 1.63: p<0.001).

Predictors of WB-MRI scan burden.

The regression analysis for predictors of WB-MRI scan burden showed that the presence of co-morbidity, psychological distress and deprivation were significant predictors in unadjusted analysis (Beta=0.242, p=0.015, Beta=0.305, p=0.002 and Beta=-0.265, p=0.005 respectively), with age, gender, and cancer type non-significant predictors and ethnicity approaching significance (Beta=0.059, p=0.535; Beta = 0.083, p=0.389; Beta=-0.122, p=0.201; Beta= -0.179, p=0.081). In the adjusted analyses only psychological distress and presence of comorbidities remained significantly predictive (Beta=0.223; p=0.025; Beta=0.191, p=0.048) with deprivation approaching significance (Beta = -0.186, p=0.059).

Discussion

As data supporting WB-MRI for cancer staging accumulates[2;3] and the technology enters clinical practice, it is important to understand patient experience and overall acceptability. Cancer patients are vulnerable and may already be suffering significant distress[1;26] which may impact on the acceptability of potentially unpleasant staging investigations.

We investigated patient experience and overall acceptability of WB-MRI compared to standard PET CT and CT in two cohorts of patients recently diagnosed or highly suspected of lung or colorectal cancer. While standard scans can distress patients,[27;28] we hypothesised that patients would find WB-MRI less acceptable given its attributes. This hypothesis was informed by related qualitative work that indicated some (but not all) patients found the scan a challenge and comparatively more so than CT and PET-CT scans.[12]

In reality, our data show that, in general, patients tolerate WB-MRI well; absolute discomfort and worry were low, and satisfaction was high. However, the burden of WB-MRI was significantly greater than for both PET-CT and CT. This differential was particularly apparent when compared to CT, the standard first line staging investigation for patients with colorectal cancer. We also found evidence that PET-CT burden was greater than for CT, particularly for items pertaining to discomfort and worry, although, as noted below, the higher prevalence of comorbidities in the lung cancer patient cohort may have influenced their tolerance of PET-CT.

Although our findings are perhaps intuitive given the known attributes of the tests, they are actually at odds with the findings of Adams et al.,[29] who compared WB-MRI with CT in patients undergoing lymphoma staging. Adams found that patients found WB-MRI more "friendly", less unpleasant, and less "worrisome" than CT, attributing the relative negative evaluation of CT to more invasive preparation - patients had an intravenous line placed and consumed oral contrast. In our study mean patient age (65 years) was considerably higher than the 50 years reported by Adams et al. furthermore, the Streamline trial WB-MRI protocols required IV gadolinium, which may also help explain discrepant findings.

We investigated factors that might predict worsened scan experience. As would perhaps be expected in a cohort of patients undergoing investigations for suspected or newly diagnosed

cancer, a significant proportion reported high level of baseline distress, and as predicted, this distress was associated with subsequent higher WB-MRI burden. Furthermore, patients with additional co-morbidity experienced greater burden. A recent review suggests that co-morbidities can reduce cancer survival and co-morbidity is associated with receiving sub-optimal treatment.[30] Our data suggests comorbidity influences the tolerability of WB-MRI which may impact on study quality and diagnostic accuracy. Further exploration of how co-morbidity influences patients' experience of cancer staging and treatment is therefore important to maximise survival. High deprivation was associated with increased WB-MRI burden in the unadjusted analysis. Deprivation is associated with higher cancer incidence and mortality, particularly for lung cancer,[31] in addition to decreased engagement with cancer screening programmes.[32] Further work to understand how deprivation influences perceived burden is important to improve experience and engagement.

Our study does have limitations. Patients recruited to the Streamline trials volunteered to take part in our questionnaire study. The proportion of patients who completed the scan experience questions was arguably quite low at 54%. However this is in line with postal survey completion rates observed in other similar studies.[33] We did consider issuing reminders to patients to increase response rate, but decided against this so as to not increase patient burden at a difficult time: patients had to complete and return two questionnaires within one month of a new cancer diagnosis. Although those who took part seem representative of Streamline trial participants overall (judged by our comparisons of registered and recruited patients), our sample may not represent all patients who may undergo WB-MRI in daily clinical practice. Patients in our study were relatively young compared to the typical age of diagnosis with lung or colorectal cancer and it is possible that scan acceptability is greater in younger patients. However, the study was done within the context of a large multi-institution study of WB-MRI, and the results are very likely to representative

of most NHS institutions. The study was powered to detect clinically meaningful differences in perceptions of burden generated by WB-MRI and standard scans, while the power calculation prior to the start of the study assumed we would be using paired samples t-tests rather than Wilcoxon signed rank tests, significant differences were still detected with the latter. Other studies have used much larger numbers to try and predict poor tolerance of MRI.[8] It is possible our null findings for some predictors (e.g. age, gender and cancer type) and findings of borderline significance for the role of deprivation in adjusted analyses, may be due to lack of statistical power to detect small effects. Patients were asked to complete the baseline questionnaire at the point of trial registration, with the post-staging questionnaire one month later. Scan timing meant that at baseline some patients had already completed WB-MRI by the time they completed the baseline questionnaire and a whole month had elapsed before they were asked to answer the post-scan evaluation questions. This may have introduced some recall bias into their responses. However, recalled experience some time after the event may have greater prediction for future health behaviours than immediate recollection.[34] Some patients may have been aware of their diagnosis at the time of completing the baseline questionnaire, when distress levels were assessed. We did not ask people whether or not they knew their diagnosis at baseline, but rates of distress among people undergoing investigations for suspected cancer are similar to those among people with a confirmed diagnosis, so this is unlikely to have affected the results observed.[1]

It would have been useful to quantify patient co-morbidity with scores such as the Charlson score.[35] However such scores are time consuming and collection of complete and clean data was not possible with our resources. As noted in the methods however, self-report measures of comorbidity have been shown to be valid[17;18] and offer a more cost-effective method of data collection than medical record-based measures.

A further limitation is that our study focused on scan experience, and although a number of questions were asked about scan acceptability, recovery time, and satisfaction with information, communication and facilities we did not examine patient views about overall appointment time, or how they viewed the time in the scanner vs. the time waiting before and after the scan. However of note, satisfaction was very high for all these items, and did not differ between scans.

Conclusions

In conclusion, patients undergoing staging for lung or colorectal cancer found WB-MRI more burdensome than standard CT and PET-CT although absolute differences in burden scores were small; most patients found WB-MRI fairly or very acceptable. Our findings demonstrate that patients with medical co-morbidities, or with pre-existing high levels of psychological distress, tolerate WB-MRI less well, and may therefore benefit from additional support.

Reference List

(1) Brocken P, Prins JB, Dekhuijzen PN, van der Heijden HF. The faster the better?-A systematic review on distress in the diagnostic phase of suspected cancer, and the influence of rapid diagnostic pathways. Psychooncology 2012; 21:1-10.

(2) Ciliberto M, Maggi F, Treglia G, Padovano F, Calandriello L, Giordano A et al. Comparison between whole-body MRI and Fluorine-18-Fluorodeoxyglucose PET or PET/CT in oncology: a systematic review. Radiol Oncol 2013; 47:206-18.

(3) Usuda K, Sagawa M, Maeda S, Motono N, Tanaka M, Machida Y et al. Diagnostic Performance of Whole-Body Diffusion-Weighted Imaging Compared to PET-CT Plus Brain MRI in Staging Clinically Resectable Lung Cancer. Asian Pac J Cancer Prev 2016; 17:2775-80.

(4) Plumb AA, Ghanouni A, Rainbow S, Djedovic N, Marshall S, Stein J et al. Patient factors associated with non-attendance at colonoscopy after a positive screening faecal occult blood test. J Med Screen 2017; 24:12-9.

(5) van Minde D, Klaming L, Weda H. Pinpointing moments of high anxiety during an MRI examination. Int J Behav Med 2014; 21:487-95.

(6) MacKenzie R, Sims C, Owens RG, Dixon AK. Patients' perceptions of magnetic resonance imaging. Clin Radiol 1995; 50:137-43.

(7) McIsaac HK, Thordarson DS, Shafran R, Rachman S, Poole G. Claustrophobia and the magnetic resonance imaging procedure. J Behav Med 1998; 21:255-68.

(8) Dewey M, Schink T, Dewey CF. Claustrophobia during magnetic resonance imaging: cohort study in over 55,000 patients. J Magn Reson Imaging 2007; 26:1322-7.

(9) Dantendorfer K, Amering M, Bankier A, Helbich T, Prayer D, Youssefzadeh S et al. A study of the effects of patient anxiety, perceptions and equipment on motion artifacts in magnetic resonance imaging. Magn Reson Imaging 1997; 15:301-6.

(10) Harris LM, Cumming SR, Menzies RG. Predicting anxiety in magnetic resonance imaging scans. Int J Behav Med 2004; 11:1-7.

(11) Shortman RI, Neriman D, Hoath J, Millner L, Endozo R, Azzopardi G et al. A comparison of the psychological burden of PET/MRI and PET/CT scans and association to initial state anxiety and previous imaging experiences. Br J Radiol 2015; 88:20150121.

(12) Evans REC, Taylor S, Janes S, Halligan S, Morton A, Navani N et al. Patient experience and perceived acceptability of whole-body magnetic resonance imaging for staging colorectal and lung cancer compared with current staging scans: a qualitative study. BMJ Open 2017; 7(9):e016391.

(13) Bigley J, Griffiths PD, Prydderch A, Romanowski CA, Miles L, Lidiard H et al. Neurolinguistic programming used to reduce the need for anaesthesia in claustrophobic patients undergoing MRI. Br J Radiol 2010; 83:113-7.

(14) Taylor SA, Mallett S, Miles A, Beare S, Bhatnagar G, Bridgewater J et al. Streamlining staging of lung and colorectal cancer with whole body MRI; study protocols for two multicentre, non-randomised, single-arm, prospective diagnostic accuracy studies (Streamline C and Streamline L). BMC Cancer 2017; 17(1):299.

(15) Goldberg D, Williams P. A user's guide to the General Health Questionnaire. Windsor, UK: NFER-Nelson, 1988.

(16) Knott C. General mental and physical health. In: Craig R, Mindell J, editors. Health Survey for England 2012, Health Social Care and Lifestyle. London: NatCen Social Research; 2013. Available from: http://content.digital.nhs.uk/catalogue/PUB13218/HSE2012-Ch4-Gen-health.pdf .

(17) Katz JN, Chang LC, Sangha O, Fossel AH, Bates DW. Can comorbidity be measured by questionnaire rather than medical record review? Med Care 1996; 34:73-84.

(18) Olomu AB, Corser WD, Stommel M, Xie Y, Holmes-Rovner M. Do self-report and medical record comorbidity data predict longitudinal functional capacity and quality of life health outcomes similarly? BMC Health Serv Res 2012; 12:398.

(19) McLennan D, Barnes H, Noble M, Davies J, Garratt E, Dibben C. The English Indices of Deprivation 2010. London: Department for Communities and Local Government, 2011.

(20) Salmon P, Shah R, Berg S, Williams C. Evaluating customer satisfaction with colonoscopy. Endoscopy 1994; 26:342-6.

(21) von Wagner C, Smith S, Halligan S, Ghanouni A, Power E, Lilford RJ et al. Patient acceptability of CT colonography compared with double contrast barium enema: results from a multicentre randomised controlled trial of symptomatic patients. Eur Radiol 2011; 21:2046-55.

(22) Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007; 39:175-91.

(23) Cohen J. A power primer. Psychol Bull 1992; 112: 155-9.

(24) Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. Med Care 2003; 41:582-92.

(25) Guyatt GH, Osoba D, Wu AW, Wyrwich KW, Norman GR. Methods to explain the clinical significance of health status measures. Mayo Clin Proc 2002; 77:371-83.

(26) Wiljer D, Walton T, Gilbert J, Boucher A, Ellis PM, Schiff S et al. Understanding the needs of colorectal cancer patients during the pre-diagnosis phase. J Cancer Educ 2013; 28:402-7.

(27)   Abreu C, Grilo A, Lucena F, Carolino E. Oncological Patient Anxiety in Imaging Studies: the PET/CT Example. J Cancer Educ 2017; 32: 820-6.

(28)   Heyer CM, Thuring J, Lemburg SP, Kreddig N, Hasenbring M, Dohna M et al. Anxiety of patients undergoing CT imaging-an underestimated problem? Acad Radiol 2015; 22:105-12.

(29)   Adams HJ, Kwee TC, Vermoolen MA, Ludwig I, Bierings MB, Nievelstein RA. Whole-body MRI vs. CT for staging lymphoma: patient experience. Eur J Radiol 2014; 83:163-6.

(30)   Sogaard M, Thomsen RW, Bossen KS, Sorensen HT, Norgaard M. The impact of comorbidity on cancer survival: a review. Clin Epidemiol 2013; 5(Suppl 1):3-29.

(31)   Faggiano F, Partanen T, Kogevinas M, Boffetta P. Socioeconomic differences in cancer incidence and mortality. IARC Sci Publ 1997; 138:65-176.

(32)   von Wagner C, Good A, Whitaker KL, Wardle J. Psychosocial determinants of socioeconomic inequalities in cancer screening participation: a conceptual framework. Epidemiol Rev 2011; 33:135-47.

(33)   Simon AE, Wardle J. Socioeconomic disparities in psychosocial wellbeing in cancer patients. Eur J Cancer 2008; 44:572-78.

(34)   Jensch S, Bipat S, Peringa J, de Vries AH, Heutinck A, Dekker E et al. CT colonography with limited bowel preparation: prospective assessment of patient experience and preference in comparison to optical colonoscopy with cathartic bowel preparation. Eur Radiol 2010; 20:146-56.

(35)   Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987; 40:373-83.

Table: 1: Demographic and psychological characteristics of participants who completed the post-staging questionnaire. Numbers are percent (n) unless otherwise specified.

	Overall	Patient cohort		Differences between patient cohorts
	N=115	L[1] n=54	C[2] n=61	
Demographic characteristics				
Age [α] (median in years (range))	66.3 (31-89)	69.7 (50-89)	64.2 (31-85)	Mann Whitney U test p=0.010
Male gender [α]	58.3 (67)	55.6 (30)	60.7(37)	X^2=0.306; df=1; p=0.580
White ethnicity [φ]	91.8 (90)	93.8 (45)	90.0 (45)	Fisher's Exact; p=0.715
IMD deprivation [α]				
1 (highest)	23.5 (27)	25.9 (14)	21.3 (13)	
2	24.3 (28)	27.8 (15)	21.3 (13)	
3	21.7 (25)	24.1 (13)	19.7 (12)	X^2=0.3875;df=4; p=0.423
4	17.4 (20)	14.8 (8)	19.7 (12)	
5 (lowest)	13.0 (15)	7.4 (4)	18.0 (11)	
Physical and emotional wellbeing				
Co-morbidity (at least one comorbid illness reported) [φ]	53.4 (55)	66.7 (34)	40.4 (21)	X^2=7.147;df=1; p=0.008
Emotional distress[φ] (GHQ-12 score of 4 or higher)	41.6 (42)	47.1 (24)	36.0 (18)	X^2=1.271;df=1; p=0.260

[1] Non-small cell lung cancer [2] colorectal cancer % is valid percent where there is missing data [α] No missing data [2] Missing data less than 5% [φ] Missing data greater than 5%

Table 2: Comparative experience of WB-MRI vs CT/PET-CT. Numbers are percent (n).

	Overall	Lung (L) [1]	Colorectal (C) [2]	Group differences (Wilcoxon sign test)
Recovery time				
WB-MRI [φ]				
Immediate	63.9 (69)	61.5 (32)[a]	66.1 (37)[b]	
Up to 30 minutes	25.9 (28)	23.1 (12)	28.6 (16)	[a] p=0.465
Over 30 minutes	10.2 (11)	15.4 (8)	5.4 (3)	
CT / PET-CT[φ]				[b] p=0.735
Immediate	65.1 (69)	58.8 (30)[a]	70.9 (39)[b]	
Up to 30 minutes	21.7 (23)	23.5 (12)	20.0 (11)	
Over 30 minutes	13.2 (14)	17.6 (9)	9.1 (5)	
Acceptability				
WB-MRI [φ]				
Very	65.2 (73)	64.8 (35)[a]	65.5 (38)[b]	
Fairly	30.4 (34)	29.6 (16)	31.0 (18)	
Slightly	3.6 (4)	3.7 (2)	3.4 (2)	
Not at all	0.9 (1)	1.9 (1)	0.0 (0)	[a] p=0.035
CT / PET-CT [φ]				[b] p=0.005
Very	77.8 (84)	75.0 (39)[a]	80.4 (45)[b]	
Fairly	21.3 (23)	23.1 (12)	19.6 (11)	
Slightly	0.0 (0)	0.0 (0)	0.0 (0)	
Not at all	0.9 (1)	1.9 (1)	0.0 (0)	

Satisfied with information received before scan

WB-MRI [φ]

Very satisfied	55.6 (60)	51.9 (27)[a]	58.9 (33)[b]
Satisfied	37.0 (40)	40.4 (21)	33.9 (19)
Dissatisfied	3.7 (4)	5.8 (3)	1.8 (1)
Very dissatisfied	3.7 (4)	1.9 (1)	5.4 (3)	[a] p= 0.169

CT / PET-CT [φ]   [b] p= 0.071

Very satisfied	57.5 (61)	49.0 (25)[a]	65.5 (36)[b]
Satisfied	34.9 (37)	37.3 (19)	32.7 (18)
Dissatisfied	0.9 (1)	2.0 (1)	0 (0)
Very dissatisfied	6.6 (7)	11.8 (6)	1.8 (1)

Satisfied with communication during scan

WB-MRI [φ]

Very satisfied	56.1 (60)	57.7 (30)[a]	54.5 (30)[b]
Satisfied	39.3 (42)	34.6 (18)	43.6 (24)
Dissatisfied	2.8 (3)	5.8 (3)	0 (0)
Very dissatisfied	1.9 (2)	1.9 (1)	1.8 (1)	[a] p=0.637

CT / PET-CT [φ]   [b] p=0.059

Very satisfied	64.2 (68)	62.7 (32)[a]	65.5 (36)[b]
Satisfied	32.1 (34)	31.4 (16)	32.7 (18)
Dissatisfied	1.9 (2)	3.9 (2)	0 (0)
Very dissatisfied	1.9 (2)	2.0 (1)	1.8 (1)

Satisfaction with facilities

WB-MRI[φ]

Very satisfied	45.8 (49)	49.0 (25)[a]	42.9 (24)[b]
Satisfied	45.8 (49)	43.1 (22)	48.2 (27)
Dissatisfied	4.7 (5)	2.0 (1)	7.1 (4)
Very dissatisfied	3.7 (4)	5.9 (3)	1.8 (1)	[a] p=0.225

CT / PET-CT[φ]   [b] p=0.480

Very satisfied	54.7 (58)	62.7 (32)[a]	47.3 (26)[b]
Satisfied	38.7 (41)	33.3 (17)	43.6 (24)
Dissatisfied	4.7 (5)	2.0 (1)	7.3 (4)
Very dissatisfied	1.9 (2)	2.0 (1)	1.8 (1)

[1] Non-small cell lung cancer, WB-MRI vs. PET-CT [2] Colorectal cancer, WB-MRI vs CT.

[φ] Missing data greater than 5%. % is valid percent.

Table 3: Comparative scan burden (WB-MRI vs CT/PET-CT). Numbers are mean (SD).

	Overall	L[1] cohort	C[2] cohort	Group differences using Wilcoxon signed rank test
Total patient burden (scores 1-7)				
WB-MRI [φ]	2.21 (1.1)	2.33[a](0.94)	2.09[b](1.18)	[a] p<0.001
CT/PET-CT [φ]	1.87 (0.98)	2.05[a](0.82)	1.70[b](1.1)	[b] p<0.001
Discomfort sub-scale (1-7)				
WB-MRI [φ]	2.51 (1.26)	2.65[a](1.14)	2.30[b](1.22)	[a] p<0.001
CT /PET-CT [φ]	1.83 (1.05)	2.04[a] (.90)	1.63[b](1.15)	[b] p<0.001
Worry subscale (1-7)				
WB-MRI [φ]	2.47 (1.32)	2.62[a](1.15)	2.23[b](1.31)	[a] p=0.208
CT / PET-CT [φ]	2.24 (1.23)	2.52[a](1.15)	2.00[b](1.28)	[b] p=0.041
Satisfaction subscale (1-7)				
WB-MRI [φ]	6.25[i](1.06)	6.27[a](0.85)	6.26[b](1.23)	[a] p=0.036
CT / PET-CT [φ]	6.49[i](0.89)	6.43[a](0.76)	6.53[b](1.01)	[b] p<0.001

[1] Non-small cell lung cancer, WB-MRI vs. PET-CT

[2] Colorectal cancer, WB-MRI vs CT.

[φ] Missing data greater than 5%

Figure One: flow diagram of participants through the study (March 2013 – July 2015)

```
                          ┌─────────────────────────────────┐
                          │  Recruited to trials during the  │
                          │  period the questionnaire study  │
                          │          was active              │
                          │             N=392               │
                          └─────────────────────────────────┘
          ┌────────────────────────┐   │
          ▼                        ▼
┌──────────────────────┐  ┌─────────────────────────────────┐
│ Did not consent to   │  │ Consented to interview and/or    │
│ questionnaire study  │  │ questionnaire study n=350        │
│        n=42          │  │ Response rate = 89.3%            │
│                      │  │ ('L'=93.1%; 'C'=85.8%)           │
└──────────────────────┘  └─────────────────────────────────┘
   ┌───────────────────────────┐  │
   ▼                            ▼
┌──────────────────────┐  ┌─────────────────────────────────┐
│ n=91 recruited to    │  │ Sent questionnaires at both time │
│ interview study      │  │ points                          │
│                      │  │ n=214                           │
│ n=3 not sent baseline│  │ (C=55.1%,118                    │
│ questionnaires*      │  │ L=44.9%, 96)                    │
│                      │  └─────────────────────────────────┘
│ n=42 sent baseline   │
│ questionnaire only * │
└──────────────────────┘
```

| No response n=71 | Completed baseline questionnaire only n =27 | Completed post-staging questionnaire only (no baseline data) n=12 (C=9, L=3) | Completed baseline and post-staging questionnaires n=104 (C=52, L=52) |

```
                                                              ┌──────────────────────────┐
                                                              │ n=103 included           │
                                                              │                          │
                                                              │ n=1 withdrawn (didn't    │
                                                              │ have WB-MRI)             │
                                                              └──────────────────────────┘
┌─────────────────────────────────┐        ┌──────────────────────────────────┐
│ * Reasons for withdrawal/ not    │        │    Included in analyses          │
│ sent follow up questionnaires    │        │                                  │
│                                  │        │          n=115                   │
│ n= 2 patient withdrew consent    │        │                                  │
│                                  │        │ (54% of those sent both          │
│ n=12 did not meet colorectal or  │        │ questionnaires;                  │
│ non-small cell cancer inclusion  │        │                                  │
│ criteria                         │        │ C=53%, 61, L=47%, 54)            │
│                                  │        └──────────────────────────────────┘
│ n=27 WB-MRI did not take place   │
│                                  │
│ n= 3 not recruited to            │
│ questionnaire study in error     │
│                                  │
│ n=1 lost to follow up as moved   │
│ abroad                           │
└─────────────────────────────────┘
```

Appendix A: 26 items for Patient Burden Scale and sub-scales (* new items for this study)

<u>Satisfaction Sub-Scale (7 items) α=0.88 (WB-MRI), =0.84 (Pet/CT), =0.94 (CT)</u>

1. I was not interested vs. I was interested

2. Loss of modesty vs. No loss of modesty

3. Not confident in staff vs. Confident in the staff

4. I was not pleased with how it went vs I was pleased with how it went

5. Undignified vs. dignified

6. Dissatisfied vs satisfied

7. Not enough privacy vs Enough privacy

<u>Worry Sub-Scale (6 items)α=0.79(WB-MRI), =0.76 (Pet/CT), =0.86 (CT)</u>

8. Worried vs. not worried

9. Agitated vs. Calm

10. Did not understand what was happening vs. Understood what was happening

11. I was worried about what they would find vs. I was not worried about what they would find

12. I was confused vs. I was not confused

13. I felt puzzled vs. I did not feel puzzled

<u>Physical Discomfort Sub-Scale (13 items)α=0.91 (WB-MRI), =0.88 (Pet/CT), =0.97 (CT)</u>

14. Felt out of control vs Felt in control

15. Uncomfortable vs Comfortable

16. The noise of the scanner was unbearable vs the noise of the scanner was fine *

17. Difficult to do what was required vs. Easy to do what was required

18. Tired afterwards not tired afterwards

19. The need to repeatedly hold my breath was unbearable vs. the need to hold my breath was fine*

20. A bad experience vs. a good experience

21. The time the scan took was unbearable vs The time the scan took was fine*

22. Claustrophobic vs. not claustrophobic

23. The injections needed for the scan were unbearable vs the injections needed for the scan were fine*

24. Undesirable side effects vs no undesirable side effects*

25. Hard to cope with vs easy to cope with

26. The need to lie still for the scan was unbearable vs the need to lie still for the scan was fine*

Appendix B: On-line Table 1: Comparison of demographic characteristics of patients who did or did not consent to participate in the questionnaire study

| | Consent to questionnaire study | | Grp diff |
	No Consent n=42	Consent n=350	
Age (median in years (range))	65.0 (36-96)	66.0 (29-94)	Mann Whitney U test p=0.585
Gender (% (n))			X^2=1.286, df=1; p=0.257
Male	9.3 (23)	90.7 (223)	
Female	13.0 (19)	87.0 (127)	
Stream (% (n))			X^2=5.451, df=1; p=0.020
Colorectal	14.2 (29)	85.8 (175)	
Lung	6.9 (13)	93.1 (175)	
Deprivation Quintile (% (n))			
1 (highest)	40.5 (17)	31.7 (111)	
2	23.8 (10)	28.0 (98)	$X^2$1.529, df=4; p=0.832
3	14.3 (6)	16.6 (58)	
4	14.3 (6)	13.1 (46)	
5 (Lowest)	7.1 (3)	10.6 (37)	

Appendix C: On-line Table 2: Comparison of demographic characteristics of patients sent both questionnaires, who were or were not included in the final analysis

	Sent both questionnaires		Grp diff
	Excluded from analysis n=99	Included in final analysis n=115	
Age (median in years (range))	65.0 (30-86)	66.3 (31-89)	Mann Whitney U test p=0.676
Gender (% (n))			X^2=3.578, df=1; p=0.059
Male	37.7 (29)	51.1 (70)	
Female	62.3 (48)	48.9 (67)	
Stream (% (n))			X^2=0.442, df=1; p=0.506
Colorectal	48.3 (57)	43.8 (42)	
Lung	56.3 (54)	51.7 (61)	
Deprivation Quintile (% (n))			
1 (highest)	60.9 (42)	39.1 (27)	
2	45.1 (23)	54.9 (28)	$X^{2=}$10.370, df=4; p=0.035
3	32.4 (12)	67.6 (25)	
4	41.2 (14)	58.8 (20)	
5 (Lowest)	34.8 (8)	65.2 (15)	